

CHAPTER 14: Drip irrigation

INTRODUCTION

In drip irrigation, water is applied to each plant separately in small, frequent, precise quantities through dripper emitters. It is the most advanced irrigation method with the highest application efficiency. The water is delivered continuously in drops at the same point and moves into the soil and wets the root zone vertically by gravity and laterally by capillary action. The planted area is only partially wetted.

In medium-heavy soils of good structure, the lateral movement of the water beneath the surface is greater than in sandy soils (Table 14.1). Moreover, when the discharge rate of the dripper exceeds the soil intake rate and hydraulic conductivity, the water ponds on the surface. This results in the moisture being distributed more laterally rather than vertically. The following water lateral spread values are indicative:

TABLE 14.1 - Type of soil and average radius of water spread laterally with drippers

Type of soil	Average radius of water spread
Light texture	0.30 m
Medium texture	0.65 m
Fine texture	1.20 m

SYSTEM LAYOUT AND COMPONENTS

A complete drip irrigation system consists of a head control unit, main and submain pipelines, hydrants, manifolds and lateral lines with dripper emitters.

Control station (head control unit)

Its features and equipment depend on the system's requirements. Usually, it consists of the shut-off, air and check (non-return) valves, a filtering unit, a fertilizer injector and other smaller accessories.

Main and submain pipelines:

The main and submain pipelines are usually buried, especially when made of rigid PVC.

Hydrants

Fitted on the mains or the submains and equipped with 2–3 inches shut-off valves, they are capable of delivering all or part of the piped water flow to the manifold feeder lines. They are placed in valve boxes for protection.

Manifold (feeder) pipelines

These are usually 50, 63 or 75 mm. Where made of HDPE, they are attached to the hydrants through compression-type, quick release, PP connector fittings and remain on the surface.

Dripper laterals

These are always made of 12–20 mm soft black LDPE, PN 3.0–4.0 bars. They are fitted to the manifolds with small PP connector fittings at fixed positions and laid along the plant rows. They are equipped with closely spaced dripper emitters or emission outlets (Figure 14.1).

FIGURE 14.1 - The mains, manifold and dripper laterals.



In general, the distribution network (mains, submains and manifolds) consists of thermoplastic pipes and fittings (PVC, PE, PP, etc.), PN 6.0 and 10.0 bars. However, for the mains, submains and manifolds, other kind of pipes can also be used, such as quick coupling light steel pipes. In the past, permanently assembled buried rigid PVC pipes were used as mains and

submains, with hydrants rising on the surface at desired points. More recently, surface-laid 50–75 mm HDPE pipes, PN 6.0 bars, have been used for the whole distribution network in smallholdings. Larger diameter PE pipes are also available but cost more than rigid PVC pipes of the same size.

The system's pressure ranges from 2.0 to 3.0 bars. Therefore, all drip irrigation systems can be classed as low pressure, localized, solid permanent or seasonal installation systems.

DRIP EMITTERS (DRIPPERS)

The drippers are small-sized emitters made of high quality plastics. They are mounted on small soft PE pipes (hoses) at frequent spaces. Water enters the dripper emitters at approximately 1.0 bar and is delivered at zero pressure in the form of continuous droplets at low rates of 1.0–24 litres/h. Drippers are divided into two main groups according to the way they dissipate energy (pressure):

- orifice type, with tiny flow areas of 0.2–0.35 mm²;
- long-path type, with relatively larger flow areas of 1–4.5 mm².

Both types are manufactured with various mechanisms and principles of operation, such as a vortex diode, a diaphragm or a floating disc for the orifice drippers, and a labyrinthine path, of various shapes, for the long-path ones. All the drippers now available on the market are turbulent flow ones.

Drippers are also characterized by the type of connection to the lateral: on-line, i.e. inserted in the pipe wall by the aid of a punch; or in-line, where the pipe is cut to insert the dripper manually or with a machine.

On-line multi-exit drippers are also available with four to six 'spaghetti' type tube outlets.

Specifications that should be stated by the supplier are:

- dripper discharge (flow rate) at the recommended operating pressure, usually 1.0 bar;
- dripper discharge versus pressure variations and the optimum length of dripper line with different spacing and slopes;
- type of connection;
- filtration requirements;
- coefficient of variation (cv) (the drippers' manufacturing variability).

Dripper emitters which are available as separate items, not built into the pipe, can be referred to as separate source point drippers.

DRIP TAPES

These are thin-walled integral drip lines with emission points spaced 10, 20, 30, 45 cm or any other distance apart, delivering lower quantities of water than the usual drippers at very low pressures, i.e. 0.4–1.0 litres/h at 0.6–1.0 bar. They are integrated drip lines where the drippers are built in the pipe walls at the desired spacing during the manufacturing process. They are ready-made dripper laterals with a very high uniformity of application. Drip tapes are made of LDPE or other soft PE materials in various diameters from 12 to 20 mm and in several wall thicknesses (0.10–1.25 mm). Thanks to a filtration system incorporated inside the tubing, they are less susceptible to mechanical and biological blockages than conventional drippers are.

POROUS-WALL PIPES

These pipes are small-sized (about 16 mm) thin-walled porous flexible hoses made from PE fibres, PVC, ABS or rubber. They permit water and nutrients under low pressure to pass from inside the tube, by transpiration, and irrigate the crops. The porous pipeline discharge is not accurate because the size of the pores varies and is not stable. They are used as lateral drip lines beneath the surface. Their application is limited although they do offer some advantages.

FILTRATION

The filtration of the irrigation water is of major importance for the normal application of this system. The solid content in the water must be removed through effective filtration in order to avoid blockage damage in the drippers. The kind of filtration depends on the impurities contained in the water and the degree of filtration required.

IRRIGATION SCHEDULING

In drip irrigation, the soil volume in the root zone is only partly wetted and the availability of moisture restricted. The soil moisture depletion should not exceed 40 percent of the soil available moisture in the late growing stages of vegetables and fruit trees, and 20–30 percent in the early stages for vegetables. However, in order to obtain higher yields, the common practice is to irrigate every day in the later stages. Proper irrigation scheduling can be arranged by using tensiometers to indicate the soil moisture tension in the root zone. This should range from 10 cbars for light soils to 25 cbars for heavy soils.

DESIGN CRITERIA AND CONSIDERATIONS

Drip irrigation is mainly applied in intensive cultivations planted in rows (vegetables, fruit trees, melons, bananas, papayas, flowers, grapes, etc.). It is not recommended for potatoes, salad leafy vegetables, groundnuts, alfalfa and other dense planted crops, although it can be applied successfully.

The drippers and/or the lateral spacing are directly related to the crop planting spacing. In most vegetable crops, the dripper spacing is identical to the crop planting spacing, i.e. one dripper per plant and one dripper lateral per row of cultivation. With drip tapes there are several emission points per plant in order to ensure a continuous wetted strip along the row. Here, the arrangement is one drip tape per row of crop.

Under drip irrigation, most of the vegetables develop the bulk of their roots in the first 30 cm depth of the soil profile below the emission point. Thus, if both the crop and the emission points along the rows are closely spaced, most of the soil volume can be sufficiently wetted with optimum results.

Where the crop is planted closely in beds, one dripper lateral per two rows might be applied with good results. Other crops planted in double rows (celery, capsicum and hot peppers) are also irrigated by one dripper lateral placed in between the rows.

In widely spaced tree orchards, the dripper spacing differs from that for vegetables. As the soil surface is partially wetted, only a part of the root system is being wetted too. The main consideration is to wet the largest possible volume of soil per tree (root system volume), not less than 35 percent, and at the same time to avoid deep percolation, beyond 50–60 cm, which is the average root depth of fruit trees under drip irrigation. The above percentage corresponds to an area of approximately 10–12 m² of soil surface with a tree spacing of 5 x 6 m or 6 x 6 m. Based on this consideration and the indicative lateral water spread figures, the dripper lateral design arrangements in tree orchards can be as follows:

- Single line per row of trees, with 4–8 drippers at approximately every 0.8–1.2 m along the line;
- Circular layout, or 'loop around the tree'. In this arrangement there is a single line per row and for each tree there is either a smaller extension line with 5–8 drippers around the tree, or a multi-exit dripper with 4–6 small emission tubes extending radially around the tree. The circle diameter can be from 1.2 to 2.2 m. Newly planted trees can have two drippers only on both sides of the trunk, 35–40 cm away from the trunk.
- Double lines per row of plants. This design is applied in banana plantations, with two dripper lines per row, one on each side, set approximately 1.2–1.6 m apart. The drippers along the lines are spaced at 0.7–1.2 m accordingly (Figure 14.2).

FIGURE 14.2 - Double lines with bananas.



COST

The cost for a complete drip irrigation installation is US\$4 000–5 000/ha. The cost of the pipes (all tubing, laterals included) is about US\$2 000, i.e. 45 percent of the total cost. The head control unit accounts for 30 percent of the total cost.

ADVANTAGES

- Water savings. The planted area is partially wetted with precisely controlled water amounts. Thus, large quantities of irrigation water are saved and the irrigated area can be expanded with the same water supply, resulting in higher income per unit of water.
- Utilization of saline water resources. With drip irrigation, low soil moisture tensions in the root zone can be maintained continuously with frequent applications. The dissolved salts accumulate at the periphery of the wetted soil mass, and the plants can easily obtain the moisture needed. This enables the use of saline water containing more than 3 000 mg/litre TDS, which would be unsuitable for use with other methods.

- Use on marginal fields. Small irregular marginal plots, remote because of land fragmentation with varying topography and shallow soil full of rocks, can be productive under drip irrigation techniques that deliver the required amounts of water and nutrients directly to the plants.
- Low labour operating requirements, reduced cultivation and weed control, and uninterrupted operation are among the other advantages of this irrigation method.

DISADVANTAGES

- High initial purchase cost.
- Good irrigation management is essential for skilled system operation, application of fertigation and maintenance of the head control unit equipment (filters, injectors, etc.).
- Emitter blockages. The first limitation on the successful introduction of drip irrigation techniques in developing countries is mechanical clogging of the emitters because of insufficient filtration of impurities in the irrigation water.

EXAMPLE DESIGN – Drip irrigation in watermelons

Area and crop

The plot dimensions are 120 x 83 m (about 1 ha), planted in the open with watermelons in rows 2.20 m apart and spaced along the rows at 0.5 m. The plot is divided into two parts, each with 54 rows 40.5 m long. There are 81 plants per row. Thus, there are 4 374 plants in each part, i.e. 8 748 plants in the whole plot and 108 plant rows.

Soil, water and climate

Heavy texture soil with low permeability (approximately 6 mm/h) and a high water holding capacity. The source of water is a nearby open water reservoir; it is of good quality but with a high impurity content of organic origin (algae). The crop growing season is from early April to early July; the evaporation pan average maximum readings are 3.3 mm/d in April, 4.64 mm/d in May and 6.13 mm/d in June.

Crop water requirements and irrigation schedule

The maximum irrigation requirements of the watermelons are during the mid-season stage and the yield formation in late May-early June, when the kc value is 1.0. The average reading for the two months is 5.38 mm/d, which

multiplied by a correction factor of 0.66 gives an ETo of 3.55 mm/d. As $k_c = 1.0$, $E_{Tc} = 3.55$ mm/d. The system's application efficiency is 90 percent.

Therefore, the daily gross requirements at peak are:

$$\begin{aligned} 3.55 \times 0.90 \div 100 &= 3.94 \text{ mm/d} \\ 3.94 \times 10 \times 1 \text{ ha} &= 39.4 \text{ m}^3/\text{d} \end{aligned}$$

The irrigation scheduling in late May is not arranged at a fixed depletion of the available soil moisture, but at a fixed interval of one day. Therefore, irrigation takes place every day and the dose is 39.5 m³. At the early stages of the growing season, the irrigation interval ranges from 4 to 2 days.

System layout

The system consists of a head control equipped with a gravel filter and a strainer, a fertilizer injector and a regulating valve. The 63 mm HDPE main line is laid on surface along the middle of the field. On this main line (which also serves as a manifold), there are 54 hydrants $\frac{3}{4}$ inch at a spacing of 2.20 m. The laterals, connected to the hydrants, are 16 mm LDPE pipes laid perpendicular to the main line on both sides, one per row of plants. Separate point source drippers are inserted in the laterals at a spacing of 0.5 m, one per plant.

Dripper characteristics:

- on-line: 4 litres/h at 1.0 bar;
- filtration requirements: 160 mesh.

Lateral characteristics:

- pipe: 16 mm LDPE, 4.0 bars PN, length 41 m;
- number of drippers: 81;
- water discharge: 324 litres/h;
- total number of laterals: 108;
- total number of drippers 8 748.

System flow and operation

For the simultaneous operation of all the laterals, the required flow is 35 m³/h. If one irrigation is to be completed in three shifts, the flow of the system is 12 m³/h, a reasonable size of flow for an area of 1 ha. The duration of application per shift at peak demand for an irrigation dosage of 39.5 m³ is 1 h 06 min. The time required to complete one irrigation is 3 h 18 min (Figures 14.3 and 14.4).