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Use of Drip Irrigation in Water Scares Region: An Overview

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Abstract: *Global population is expected to increase by about 30% by the year 2030, and as a result, demand for food will increase Major constrains to meet the increasing food demands of the population, is irrigation water and land scarcity. A possible approach to overcome constrains could be through improving performance of adopted irrigation systems or introductions of better ones. Water is a key production input for irrigated agriculture. It is expected that in the future the demand for water for various uses will continue to increase, intensifying the competition for available water resources. To meet the future challenge of reduced water availability, water use efficiency should be increased significantly by using water efficient irrigation systems. This paper focuses on the use of drip irrigation in water scares regions.*

Keywords: *Water, food, population, drip irrigation, efficiency*

I. Introduction

Drip irrigation can be defined as the application of water through emitters on or below the soil surface at small operating pressure and its field application efficiency is 90$ as compared with 60-80% for sprinkler and 50-60% surface irrigation[1]. Drip technology improves irrigation efficiency by reducing evaporation from the soil surface, reducing or eliminating runoff and deep percolation, and eliminating the need to drastically over-irrigate some parts of the field to compensate for uneven water application [2].
With drip irrigation, water is conveyed under pressure through a pipe system to the fields, where it drips slowly onto the soil through emitters or drippers which are located close to the plants. Only the immediate root zone of each plant is wetted. Therefore this can be a very efficient method of irrigation (Figure 1). Drip irrigation is sometimes called trickle irrigation. It involves dripping of water onto the soil at very low rates (2-20 litres/hour) from a system of small diameter plastic pipes fitted with outlets called emitters. Water is applied close to plants so that only part of the soil in which the roots grow is wetted (Figure 1), With drip irrigation water, applications are more frequent (usually every 1-3 days) than with other methods and this provides a very favourable high moisture level in the soil in which plants can flourish.

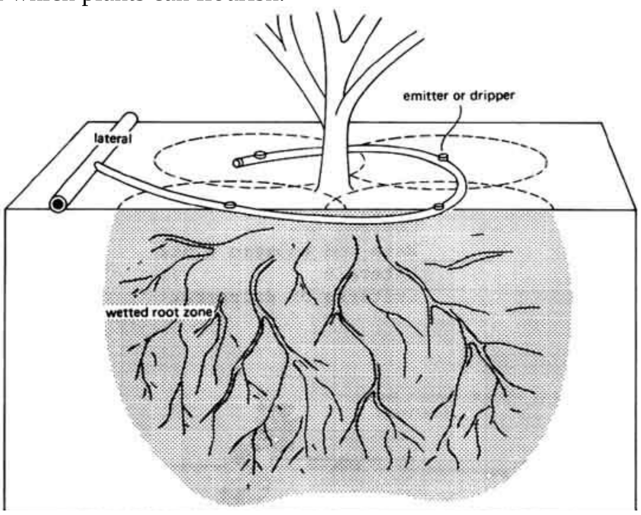

Fig. 1: Water application in drip irrigation

Suitability of Drip Irrigation

Drip irrigation is most suitable for row crops (vegetables, soft fruit), tree and vine crops where one or more emitters can be provided for each plant. Generally only high value crops are considered because of the high capital costs of installing a drip system. It 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. It 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. It 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.

Limitations of Drip Irrigation

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. If this is not so then filtration of the irrigation water will be needed. Blockage may also occur if the water contains algae, fertilizer deposits and dissolved chemicals which precipitate such as calcium and iron. Filtration may remove some of the materials but the problem may be complex to solve and requires an experienced engineer or consultation with the equipment dealer.

Drip Irrigation System Layout

Layout plan of a drip irrigation system is shown in figure 2.

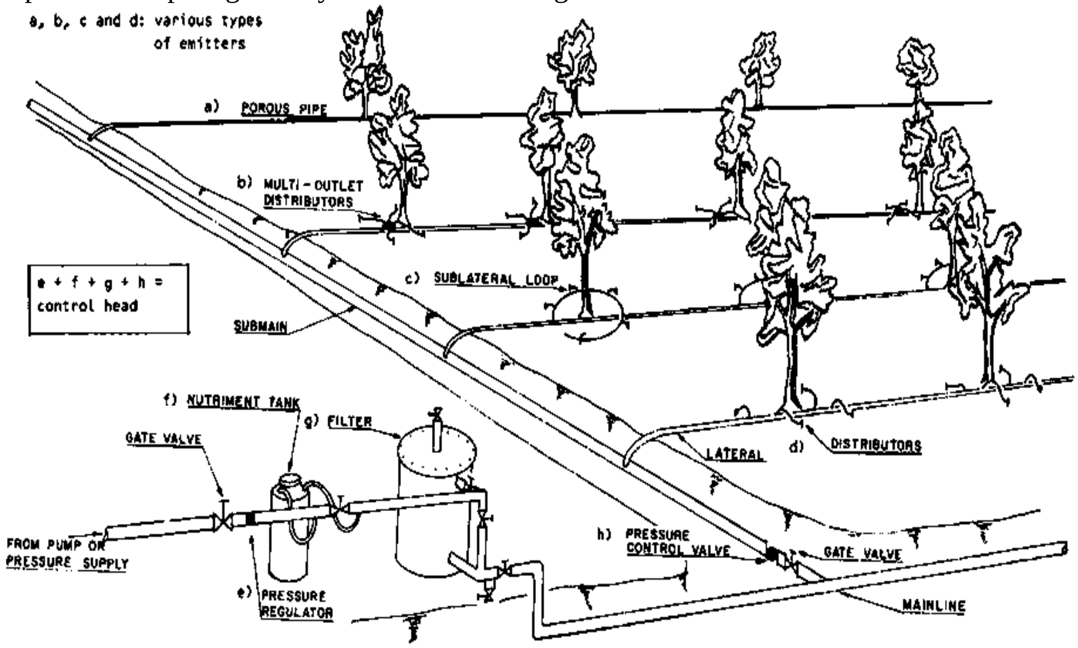

Fig. 2: A typical drip irrigation system layout

Global population is expected to increase by about 30% by the year 2030, and as a result, demand for food will increase [3]. Major constrains to meet the increasing food demands of the population, according to [4], are irrigation water and land scarcity. A possible approach to overcome constrains could be through improving performance of adopted irrigation systems or introductions of better ones.

II Review of Literature

Advantages of Drip Irrigation

The drip irrigation system benefits the environment by conserving water and fertilizer. A drip irrigation system can save as much as 80% of the water normally used in other methods of Water is generally applied on the surface. Another advantage to drip irrigation is that there is less evaporation from the soil, especially when drip irrigation is used with plastic mulch. Water is applied more evenly throughout the field, it requires some expertise to install and operate a drip system

On-Field Consideration

The selection of the system is related to the size of the farm, water quality, slope of the land, and the value of the crop. The system should be compatible with the grower’s cultural practices, such as crop rotation, access to the field, unless the cultivator is willing to change them. The economic benefit of drip irrigation will only be realized if an increase in production potential or a decrease in operating costs exceeds the increased cost of installing up the system. If the cost of the system can be spread over multi-crops and uses, then the cost is easily justified.

Water Source

The emitters in a drip system have small diameters that can easily be clogged if suitable filters are not used in the system. Therefore it is essential that a water test is performed prior to use the system. Organic materials, such as plant materials, algae, small living organisms and inorganic sand, silt, and

clay are the primary concern if the source of water is from surface water such as a pond or channel Inorganic materials such as salts are usually the primary concern if the water comes from groundwater.
Water Test
A water analysis should be done before the system is used The water should be tested for at least the following: calcium, magnesium, pH, carbonates and bicarbonates, iron, living organisms, and size of the particulate matter.
The results of the water test determine the type of filtration system needed. The pH, calcium, and magnesium concentration will affect the solubility of certain fertilizers.

Slope of the Land

A slope of 2% or less is the ideal for drip irrigation. An elevation change of 0.6 m can cause a 1 psi change in pressure. The length and number of lateral lines, the pump size, and pressure regulators are chosen based on the slope. Different emitter sizes or spacing between emitters can be adjusted to accommodate slopes.

Soil

One of the advantages of drip irrigation is that it can be adopted to various soil types. The soil type determines the soil wetting patterns. The duration and frequency of irrigation are also determined by the soil type. Over watering can move fertilizer away from the root zone. On sandy soils, the water never moves laterally more than 25 cms. In sandy soils, irrigate more frequently, but run the water for a lesser amount of time. In heavier soils, irrigate less often, but run the water for a longer duration.

Designating a System

The main components of a typical drip system are the pump, flow meters, main and sub-main lines, drip tape, pressure valves, filters, fertilizer injectors, and flushing manifolds.

Drip Tape

Two goals for a drip irrigation system are to apply water uniformly over the field and to have the water running through the system only as long as necessary to properly wet the field. The uniformity of the water flow depends on the spacing and the type of emitters used with the tape.
The length of the drip lines is another important consideration. The length is determined by the pump size, the field size(s), and the slope of the land. Any one of these factors will influence wetting uniformity because the emitters will discharge water at different rates if there are changes in pressure along the line. Because of variation in water pressure, tape is rarely laid out longer than a length of 400 feet. The choice of tape thickness, measured in mm is based on length of the tape to last and the expected highest water pressure in the lines.
The longer the tape is in the ground, or the higher the pressure in the lines, the thicker the tape should be. Tape thickness is usually between 4 and 10 mm Tape life is usually 2 to 3 years depending on how well the system is managed in the field.

Placement of Drip Tape

There are three decisions to be made regarding placement of the drip tape:
1. the distance from the plant in the row,
2. whether to bury the tape or place it on the soil surface, and
3. the depth to bury the drip tape. Whether the tape is laid on the surface or buried beneath the soil, there are a few general guidelines to follow. The tape should be placed as close to the plant as is practical for the specific crop. Twelve inches is the maximum distance away from the plant row - most tape is placed between 6 and 12 inches away.

The tape should be placed so that the emitters are pointed upward so that soil, silt and clay will settle away from the emitters after the water stops flowing. Tape can be laid on the surface, especially if it is used in conjunction with black plastic. The advantages are that it is easy to install and to make repairs.
Drip tape is usually buried between 15 cm and 25 cm deep, How deep the tape should be buried in a given field is determined by the crop, the soil type, the root pattern of the crop, soil wetting patterns, and the tilling practices used in the field.

Pumps

The purpose of a pump is to deliver water evenly at the correct flow rate and pressure. The pump capacity is determined by the crop's water requirements, the efficiency of the whole system, and the largest acreage to be irrigated by the pump at a given time. There is a rule of thumb that the larger the capacity of the pump, the more efficient it is. However, there is a point where efficiency levels off and more capacity does not bring any benefit.

Filters

The choice of filter is based on the quality of the water passing through the system. If the water is loaded heavily with suspended solids, then a sedimentation tank is recommended. This would allow some of the course materials to settle out before it reaches the filter. However, a sedimentation tank should not be the only method of filtration for the system.

Sand Separator

If the sediment load is high, than it is a good idea to prefilter the water with a vortex sand separator before running the water through another filter. A sand separator causes the water to swirl in a vortex. This forces sediments to drop to the bottom of the container.

Screen Filter

Screen filters are inexpensive and easy to install. Mesh filters work well if there are moderate to low contaminants in the water such as those coming from a well. Screen filters have a limited ability to store contaminants. Thus, if the water comes from a river or a holding pond, the screens will have to be flushed often. This could result in considerable down time in the system. Clean water must be used to clean the system!

Mesh screen sizes are between 20 and 200 mesh. The larger the number, the smaller the particle the screen will filter out. The screens are made from stainless steel, nylon, or polyester. The maximum flow rate through a screen is 200 gpm/sq. ft. of screen.

Sand Filter

Sand filters are more effective than screen filters if the contaminant load is moderate to heavy or there are sources of heavy inorganic or chemical substances in the water. A sand filter can run longer than a screen filter before it needs to be cleaned. There is less down time in the system. The filters can be set up in pairs so that clean water from one filter is used to flush the other filter.

For most systems the average size filter is 20 gpm/sq. ft. The type of sand filter used in the system is based on how much the water needs to be cleaned. It is made up of crushed, sharp edged silica or granite. The sand never needs replacing unless it is contaminated by oil or other chemicals. Sand filters can remove particles smaller than those that can be removed from a 200 mesh screen filter.

Flow meters

A flow meter measures the volume of water passing through the system. The system can be programmed to shut down as soon as the flow meter registers that a predetermined volume of water has passed through it. This saves water over the long run and decreases the likelihood of nutrients leaching from the root zone. The flow volume for a single irrigation event is determined by the needs of the crop and the size and efficiency of the system.

Propeller Meter

There are several types of flow meters. The most commonly used flow meter is the propeller meter. It requires installation in a straight section of pipe and for the pipe to flow at full capacity in order to register accurately. Propeller meters can become clogged if there is debris in the water. Variation in water pressure will alter the amount of water registered on the meter.

Pipe/Mainlines

Mainlines are made of either PVC pipe or lay-flat hose. Their purpose is to deliver water to the submains and laterals. The diameter of the pipe is determined by the distance the water needs to travel and the pressure requirements of the system. The larger the diameter of the pipe, the more expensive it is. The longer the pipe and the more elbows or junctions, the more loss due to friction, which then causes a gradual loss in pressure.

Check Valves and Pressure Regulators

Valves control the direction of water flow. They are used to prevent water from flowing backward into a well after the system is shut off. Pressure regulators help maintain a constant pressure as the water flows through the system. Pressure relief valves prevent sudden changes in pressure from damaging pipes. Vacuum-relief valves are installed to prevent soil from being sucked into the emitters when a vacuum is created after the system is shutoff.

Running the System

The drip irrigation system should be properly operated.

Every crop requires different amounts of water to grow. The amount of water the crop requires for optimal production depends on the crop, the region of the country the crop is grown in, and the weather patterns for the growing season and soil type. Calculating how much water to apply depends on the evapo-transpiration rate of the crop and the soil moisture content.

An important point to remember with drip irrigation is that the water is applied near the plant and that there is very little available moisture outside of the root zone. The root zone of a specific crop is much closer to the plant under a drip system than with other irrigation methods or where there is significant rainfall during the growing season. Soil moisture should be measured in the root zone, not in the furrows away from the plant. During periods of warm weather, the moisture in the root zone can be rapidly depleted even though there is sufficient moisture next to the plant.

One of the reasons for using drip irrigation is to decrease the amount of water applied to the field. This aids in weed control and decreases surface run-off. The way to measure the amount of water that a plant has used is to measure the evapo-transpiration rate, also called crop water use. Crop water use means the amount of water used by the crop in a given period of time. This includes the amount of water that has evaporated from the soil surface and the amount of water that had transpired from the leaf's surface. Yields are gets reduced if the plant receives less water than required for optimum growth.

Soil Moisture

Monitoring the soil moisture is essential to determine how much water is required in the next irrigation instalment. and to determine whether the field is getting too wet or too dry, both indicate that the irrigation system is not functioning properly. Soil moisture can be measured with tensiometers.

Tensiometer

A tensiometer is the most common tool used by growers. A tensiometer is a plastic pipe with a ceramic cup at one end and a vacuum gauge at the other. The cup is wetted to saturation; then the pipe is filled with water. The pipe is inserted into the ground at the root zone. A rule of thumb is to place the tensiometer about six 15 cm inches from the drip tape at a depth of one-third the entre root zone depth. As the soil becomes wet or dry through irrigation or rain, the change in the water level of the pipe is registered on the gauge. The higher the reading on the tensiometer, the drier the soil. If the tensiometer reading is getting higher as the season progresses, then the soil is too dry; if the reading is decreasing as the season progresses, then the soil is too wet.

Frequency of Irrigation

The soil should be irrigated to keep the soil moisture level at a constant level.. Generally, the plant should never be water stressed. Irrigation is more frequent under drip irrigation than more conventional irrigation methods because the roots remain close to the emitters. An irrigation schedule is based on the climate, the plant, and the soil. The table below shows the rule of thumb for irrigation.

Fertigation

Fertigation is the word used to describe the injection of chemical fertilizer into irrigation water. Nitrogen and potassium are available in liquid or soluble solid form and can be applied through a drip system, though phosphorus is usually broadcast at the beginning of the season. Anything injected into the water must go into solution or the system can become plugged. Injection should always occur upstream of the main filters so that undisclosed materials can be screened out.

Fertilizer should be injected into the system during the last phase of a scheduled irrigation with three quarters of an hour to an hour of water with no fertilizer after that. in order to ensure that all the fertilizer is applied and none remains in the tubing. Fertilizer in the tubing can encourage the growth of algae and other organisms. There are several ways to inject chemicals into the system The five main types of injectors are: Chemical injection pumps, venturi applicators, pressure differential tanks, gravity injectors and bladder tanks.

III Conclusions

Efforts should be made to improve irrigation efficiency through new technology. Drip irrigation increases the yield of crop, reduces the incidence of disease, and improve crop quality Drip technology improves irrigation efficiency by reducing evaporation from the soil surface, reducing or eliminating runoff and deep percolation, and eliminating the need to drastically over-irrigate the field. Its field application efficiency is 90% as compared with 60-80% for sprinkler and 50-60% surface irrigation.. Plant growth and yield can be enhanced through the use of drip irrigation Weed growth can be reduced by using drip irrigation.. Salinity problems can be mediated with drip irrigation Drip irrigation requires lesser energy as compared to highly pressurised sprinkler irrigation system. Drip irrigation system is very adaptable to difficult soil and terrain conditions.

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