Drip Irrigation Systems

An Israeli engineer Symcha Blass is credited with inventing "drip" or trickle irrigation in the 1940s. Since that time, it has come to be regarded as the least resource intensive and most beneficial form of irrigation. Drip irrigation differs from other forms in that it applies water at a very slow rate, directly to the root system of the crops, thus reducing the amount of runoff and evaporation. This makes more water available to the growing plant. Because of the slow rate of application (.05-.10 inches/hour), drip irrigation is done much more frequently, in some areas every day. This keeps the moisture content near the plant at more constant levels decreasing the likelihood of moisture shock. In this paper we address the specifics of planning and implementing a drip irrigation system, as well as discussing some ethical questions about irrigation.

Drip Irrigation Advantages

Requires 30 - 50% less water than other methods.

Requires less energy for pumping. Both volume and pressure is less than other systems.

Because flow rate and pressure are lower, smaller pipe and lower pressure rated pipe can be used.

Better control of soil moisture and better precision of moisture placement is also possible.

Plant foliage and fruit doesn't get wet which helps with pest control and disease prevention.

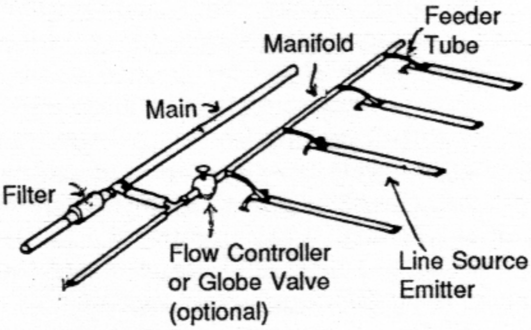
Area between the rows is unirrigated reducing weed problems.

Less labor intensive than other methods.

Field operations such as harvesting can be continued while irrigating.

Fertilizer can be supplied through the system.
Irrigation can be done on sloping terrain without runoff and accompanying erosion.

Wind does not affect the wetting pattern.



Typical Drip Irrigation Setup

Drip Irrigation Disadvantages

Requires very clean water. The small openings or paths in an emitter are subject to clogging by soil particles, organic matter, minerals and sediment in the water and algae growth.

Soil moisture distribution is limited. The volume of the soil wetted is affected by soil type, emitter or orifice discharge, distance between emitters.

Animal, rodent, insect, and/or mechanical damage may occur.

Generally, not suited or recommended for close growing crops such as grasses.

Requires a higher level of design and management than other systems.

Initial and annual investment may be higher than for other types of irrigation systems.

Soil Water Loss

Soils loose water by
1. surface evaporation and
2. plant absorption
   a. some to growth and development
   b. some lost through transpiration

Evapotranspiration Rate (ET) -- indicates how quickly soil is losing water. It is calculated from the average temperature, wind speed, humidity, precipitation, and percent of ground covered by foliage and is expressed in units of inches (or millimeters) per unit time. Plants transpire considerably to remain cool in dry sunny weather. The evapotranspiration rate can vary from 0.10 - 0.25 inches per day from May to September, This water is removed daily from soil

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moisture storage unless replaced by rain or irrigation. Root depth is also an important factor which defines the depth (and volume) of soil from which moisture is withdrawn. Shallow plants have fewer moisture reserves than deeply rooted varieties and need inputs of moisture more often.

In temperate areas such as Appalachia continuous irrigation will probably be unnecessary. Supplemental moisture may only need to be added as necessary in midgrowing season, when crop moisture requirements are greatest and the weather is driest. Many people begin irrigation in late May or early June, but for supplemental purposes our driest time is late July through August. Checking the soil for moisture content on a regular basis will help insure that irrigation is begun early enough to avoid moisture shock to the plants.

Field Capacity -- is the amount of water held by a soil after being wetted by rain or irrigation and excess water has drained away.

SOIL MOISTURE HOLDING CAPACITIES (in inches of water held per foot of soil depth)

very coarse sands	0.40 - 0.75
sandy loams	1.00 - 1.50
very fine sandy loams; and silt loams	1.50 - 2:30
sandy clays and clays	1.60 - 2.50
peats and mucks	2.00 - 3.00

Coarse soils have little reserve moisture.

NOTE: Using mulch in conjunction with drip irrigation can greatly reduce moisture lost to evaporation.

Planning Your Drip Irrigation System

There are three considerations for a successful system: proper planning & design, proper installation, and proper operation & maintenance. After deciding to install a drip irrigation system, the first step is making a field plan. Factors to consider include -- size and shape of the area, elevation contours, and location of water source relative to the field. Other considerations: soil type(s), climate, power supply, crop, row and cross row spacing, single or double row and field layout. Of particular importance are:

1 The moisture storage capacity of soil and the soil and plant moisture losses.
2. Moisture considerations for each crop
3. System components must be identified and designed. The system must be laid out for the most efficient water delivery.

Of course any decisions will be determined by budget. Never buy more equipment than you need, but do try to choose a system that can be modified to meet changing circumstances. The companies who sell drip equipment will often either design a system for the customer or assist with these decisions. Before developing you plan make a scale drawing of the garden or field to be irrigated. This is necessary to determine how many feet of tubing and the number and type of emitter to be used.

Equipment

1. *water supply* -- Potential water sources for drip irrigation systems included ponds, streams, creeks, ditches, groundwater and municipal treated water. The cleaner the water, the less filtration will be required and the potential for clogging will be reduced. Groundwater is generally of good quality, but it may contain some sand, sediment or chemical contamination. Running surface water (streams, creeks, etc.) has a large amount of suspended particles. Large ponds will have lower levels of suspended solids. Many sources recommend using municipal water for drip irrigation because of the low particulation levels and the chlorine reduces the potential for algae growth in the irrigation line (See Ethical Considerations). Any potential water source should be tested for chemical contamination before the irrigation plan is made.

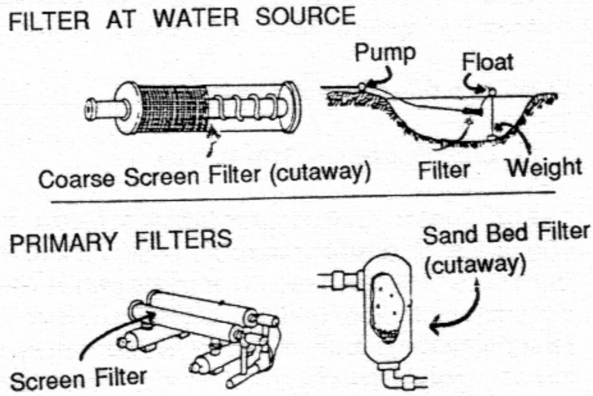
2. *pump and power source (or gravity)* -- Most irrigation systems will require a pump and a power unit. Extremely hilly or mountainous terrain may allow for the use of gravity. However, in less ideal situations two types of pump are recommended: for pumping water from a source that is on the surface or groundwater depths of less than 15 feet use the straight centrifugal or self-priming centrifugal pump. If the source is more than 20 feet deep a submersible or deep-well turbine pump is recommended.

There are several factors to be considered when choosing a pump: total pressure of the system, volume of water required, and the type of power unit. The total dynamic (pressure) head is calculated using: elevation head (total difference in elevation between the water source and the higher emitter location), friction head (pressure drop resulting from water flowing through the pipe, fittings, and valve) and pressure head (pressure required at the most distant emitter).

3. *filters* -- All types of drip irrigation equipment and almost all water sources will require filtration of some type. The filters are used to remove suspended particles in water, but have no effect on dissolved minerals and bacteria. There are two types of filters. Primary filters are located immediately downstream near the pump. Secondary filters are located nearer the field and several secondary filters may be used.

Filters can be installed in ground water sources on the intake side of submersible and turbine pumps. These will remove sand and other suspended particles, which could damage the equipment. Filters to be used on the discharge side of a pump include sand filters, screen filters, "y" type line strainers, line cartridges and sand separators. The type and size of the emitter-orifice and the water source will determine the type of filter to be used. The manufacturer's recommendations will be invaluable in making this decision. A good rule is to use a filter that removes all particles greater than 1/10 the diameter of the smallest passageway in the system.

Strainers (or screen filters) -- Most pumps will have a strainer on the suction pipe for removal of large particles. Effectiveness is determined by the slot or screen opening and the length or diameter of the strainer. Float the strainer 18 - 24 inches below the water surface will reduce the volume of suspended particles (in surface sources). These filters will only remove small amounts of sand and suspended particles and should not be used if large quantities of algae are present. Fine screens will clog more quickly than coarse. To reduce the frequency of cleaning the filter install two or more in parallel or use a screen with a large surface area.



Some Common Types of Filters

4. *pressure regulators and gauges* -- The pressure regulator reduces the system pressure to the proper operating pressure. They need to be positioned on either side of the filter and can indicate its condition. A decrease in outlet pressure signals a clogged filter. Pressure relief valves are not always necessary, especially on flat terrains or at low pressure. They will usually be located at higher points in the lines and at the ends of the lines.

Vacuum relief gauges (vacuum breakers) prevent potential contamination of a water source, which might occur if negative pressure occurs in the line. This is a must if municipal or well water is used. A 1-inch vacuum relief valve for each 25 gallons per minute of flow should be installed downstream from the valve that controls flow into the irrigation area.

5. *control valves* -- All systems need an on/off valve. The simplest type of valve is a gate valve. In very small systems where pressure is near constant the gate valve can be used as a pressure regulator. The more sophisticate solenoid valves (electric or hydraulic) are essential for any automation of the operation, or if the grower wants to zone the fields. Zoning allows separation of crops according to water needs, thus those with high water requirements can be watered more frequently. Again, in Appalachia where irrigation is likely to be supplemental, zoning is of minimal importance. Solenoid valves can be activated manually but usually use an electric controller.

6. *distribution piping* -- The main waterline carries water to the field lateral system. It can be a length of ordinary garden hose or flexible 1/2- inch PVC tubing. The main line can be run underground, out of sight and protected from the sun. With large drip systems decisions must be made as to whether more than one main line is necessary to maintain consistent pressure. Laterals of 1/2 inch to 3/4 inch polyethylene pipe may be used for distribution from the main to the rows (13-16mm - 19-24mm).

7. *emitters or local delivery* -- In drip (trickle) irrigation water is applied in low volume at low pressure. Because of this the necessary emission device must counteract the pressure differences caused by topography and friction loss and yet not be subject to clogging.

There are two types of emitters:

a. Line Source -- Drip tubing

Line source emitters are holes (orifices) or tubes of uniform size and spacing down the length of a single or double chamber tube, or small openings in a porous tube. This type of emitter is used with closely spaced row crops and is commonly used with annual row crops. Discharge rate is normally in gpm (gallons per minute) per 100 ft of pipe with a variance of ± 0.1 - 1.2 gpm. The spacing of the plants and orifices determines the volume of water delivered. Most of these systems use PE (polyethylene) plastic pipe. Water pressure ranges from 2-30 psi, (usually 15 psi). Row length is limited to 1000 ft or less with installation on flat terrain, on the contour or gentle slopes. If installed on sloping ground the laterals should run downhill from the supply (header) pipe. The pipes are installed on or below the ground surface. The in-field line source laterals are one use. The low cost of tubing and the problems of retrieval, storage and the potential for clogging can make it uneconomical to reuse.

b. Point Source

Point source emitters are usually used on tree and vine crops or ornamentals which are not spaced closely. The individual emitter may be attached to a pipe or installed in-line. Line pressure is dissipated through the emitter in several ways to achieve the desired low flow rate. These include long narrow paths, vortex chambers, small orifices and a variety of other means. While some emitters have orifices of varying size most are fixed. Some will allow medium sized particles to be passed and flushed from the system. Some are self flushing at low pressures but others may have to be manually flushed. Operating pressure is between 5 - 60 psi with the normal range being 10-25 psi. Flow is from 0.5 - 2.0 gph (gallons per hour). Some systems have discharge rates up to 10 gph. Most of these point source systems require 100-200 mesh filtration but there are advertisements of types that require only 30 mesh filtration. Conventional point source emitters have uniform discharge over a narrow range of pressure. When point source emitters are installed on rolling topography, pressure compensating emitters are recommended. They are more expensive but have approximately the same discharge over a range of pressures.

8. *controllers and moisture measuring devices* -- In regions where irrigation is done frequently many growers are automating their drip irrigation systems. Controllers, which may be a simple time clock, volume meter or expensive computer equipment are used to turn the system on and off automatically. Highly mechanized systems may even use soil moisture measuring equipment to control the operation. Tensiometers and electrical resistance are the most frequently used devices. The tensiometer measures soil water tension (which increases as soil moisture decreases). Electrical resistance blocks are used in fine textured soils where the function of tensiometers is questionable.

Hard Water Tip

In systems with point source emitters, hard water can precipitate calcium carbonate which eventually causes clogging. Rather than discard the clogged emitters soak them in vinegar. This will desolve the deposits so the emitters can be reused indefinitely.

Simple Drip Irrigation

While modern methods of drip irrigation were developed in the 40s and 50s, its roots are actually much older. Native Americans in the Southwest practiced "pitcher irrigation". Near the plants to be watered, large unglazed earthenware jugs were buried leaving the mouth exposed at soil level. The jug was filled with water and covered to prevent evaporation. The water seeped slowly through the porous pottery to the roots. For the family or small market gardener a modern form of this type of drip irrigation can be done simply and inexpensively. Plug the bottom hole in a large unglazed clay pot and bury it. Covering it with a saucer will prevent evaporation. Or for a more convenient method use 1-gallon plastic milk bottles. Punch a few small (pencil lead size) holes in the bottle, fill it with water and set it on the surface of the soil over the plants roots. A good method is to use one bottle per two plants, placing the jug between them. This method is particularly useful for individuals with water supplies that contain suspended particles.

Ethical Considerations

In any treatment of the subject of irrigation attention must be given to ethical considerations. It is true that in certain climates, or at certain times of the year, the decision to irrigate can mean the difference between food on the table or losing the crop. However, with rising concern over the availability and safety of surface and groundwater stores, how and when the grower chooses to irrigate can have far-reaching impacts. It is currently estimated that in the United States 90% or greater of available water is used for agriculture. Because of extensive chemical contamination, part of the price for this highly industrialized society, safe water for human consumption is at a premium. In light of this we must place the uses for our water on a priority list, with drinking water at the top of the scale. It is unthinkable to use large quantities of drinking-quality water to irrigate crops. The sources consulted in the writing of this paper accepted that drip irrigation cannot be done with any success without the use of municipal water. One of the primary requirements of a drip irrigation system is a clean water supply with as little particle or biological contamination as possible. Of drip irrigation water sources municipal water is listed most desirable and running surface water as the least. In rural areas where other sources of water are available, (ponds, lakes, streams, etc.) using sprinkler systems rather than drip irrigation is a more common practice.

We discussed this issue with an active member of the Kentucky Organic Growers Association and she described her decision to change from drip back to sprinklers. Kathy Aman had a drip irrigation system using municipal water for three years. She said that, while it provided more consistent moisture for her crops, the expense was too great so she returned to a sprinkler system using a farm pond. She brought up another concern -- the amount of waste generated in the use of drip irrigation systems. Although T-tapes work well, they can generally only be used one season, at the end of which they are pulled up and discarded. It has been suggested that the tapes can be used a second season if great care is taken when pulling them out of the field, but this is questionable. The tapes will usually be damaged from the stresses of just being in the field. On the surface, heavy rains, and leaf fall will almost inevitably result in clogging and the exposure to weather and sun will damage the plastic. Buried, the tubes will still be exposed to clogging from rain carried particles, as well as additional damage from rodents and insects. If solid piping is used, as in point source irrigation for tree crops, damage from external sources is much less. However, drip irrigation equipment placed in the ground to be used with tree crops, berries, grapes, etc. is expected to stay in the ground for the life of the crop -- usually 10 - 20 years. This is not an option for annual crops. So, at the end of a season the farmer is left with a large pile of plastic tubing, that is for the most part beyond re-use and non-recyclable. Besides the expense of buying new T-Tapes every year, the farmer must not ignore the implications of using and discarding large quantities of petroleum based plastic. There is a type of retrievable drip tubing with a heavier construction than the t-tapes, which uses in line emitters. This system is cost prohibitive and doesn't seem to be in use around this area.

With our human tendency to manipulate the environment it is easy to forget that we, as do all species, must learn to live within our present ecosystem not alter it to suit ourselves. In regard to water issues, this involves choosing crops that are suitable for the climate and practicing water conservation.

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