

Lecture 16

Trickle Irrigation System Components & Layout

I. Introduction and Descriptions

- “Trickle” and “drip” are terms used to describe what can be generally called “micro-irrigation systems”, in which water is applied in relatively precise quantities and precise times and at precise locations
- Land-leveling costs notwithstanding, trickle irrigation systems are usually the most expensive types of on-farm water application system to install
- They can also be expensive to operate and maintain
- Usually, trickle irrigation systems are installed in areas where water is scarce and or expensive, crop value is very high, or topographical and other conditions might preclude the successful use of other types of irrigation systems
- Not all micro-irrigation systems are complex and expensive
- Labor-intensive forms of micro-irrigation continue to be practiced in many areas of the world, especially for vegetable and other “cash” crops
- For example, people may carry water in buckets or shoulder harnesses to carefully pour at each plant in a field
- Or, porous pots are buried at regular intervals along rows and filled with water individually, which seeps out into the surrounding soil
- Sometimes water is merely splashed onto crop beds by hand

II. Advantages and Disadvantages of Trickle Systems

Advantages

1. Significant water, fertilizer, and operating cost (labor and power) **savings** are *possible*
2. Ease of field **operations** due to reduced weed problems and non-wetted soil surface (e.g. strawberries)
3. Ability to apply **saline water** because of frequent (daily) irrigation; thus, soil water salinity is nearly the same as the irrigation water salinity
4. Ability to operate on **steep slopes** and rough terrain
5. The ratio of crop yield to evapotranspiration can be higher under trickle irrigation because of reduced soil surface evaporation, continuously high soil water (near FC), and lower root zone salinity due to frequent application
6. Relatively easy to automate the system
7. Can be less labor intensive than some other irrigation systems

Disadvantages

1. Systems are **expensive** to purchase and install (\$1,000 to \$6,000 per ha)
2. Susceptibility to **clogging** of emitters, which usually have very small openings – so, it is important to spend time and money on maintaining the system, applying chemicals, and keeping filters clean
3. Possibly low distribution **uniformity** due to low operating pressures and possibly due to steep slopes, especially along laterals, and due to clogging
4. Where laterals are on steep slopes, the water will drain out the downhill end at every startup and shut-down.
5. Soils with very low intake rates will exhibit ponding and **runoff**
6. **Salt** tends to accumulate at the soil surface and around the wetted area -- when it rains, these accumulated salts may be driven into the root zone
7. These systems tend to require more capable and diligent **management** because of the susceptibility to clogging, and because the systems are usually designed to operate continuously during peak ET periods (can't afford to let the system shut down during these periods). These systems do not usually take full advantage of the soil storage (buffer) capacity.

III. Trickle System Components

- The following is a list of many of the common components found in modern trickle irrigation systems:



1. Pump & motor
2. Control head
 - Valves
 - Filters and Screens
 - Chemical Injection Equipment
 - Flow Rate or Volume Meters (U/S of acid injection)
3. Mainline
 - Submains
 - Manifolds
 - Laterals
4. Water applicators
 - Emitters
 - Bubblers
 - Sprayers
 - Misters
 - Others



bubbler

5. Other equipment

- Valves & air vents
 - Vacuum Relief Valves
 - Pressure Relief Valves
 - Various Pipe Fittings and Appurtenances
- Not all trickle irrigation systems will have all of these components
 - For example, some systems are gravity-fed and require no pumping
 - Simple systems may not have submains and manifolds
 - Some systems do not have pressure relief or other types of safety valves
 - Systems with relatively dirty water will have multiple levels of filtration, others may have only minimal screening

IV. Types of Water Applicators

- The basic purpose of water applicators in trickle irrigation systems is to **dissipate energy**
- This is because lateral pressures must be high enough to provide adequate uniformity, yet emitters must yield small flow rates
- Otherwise, one could simply punch holes in a plastic pipe (in some cases this is exactly what people do)

1. Drip Emitters

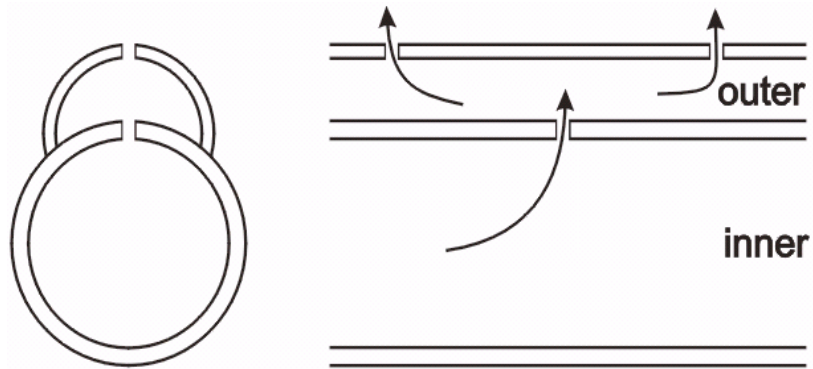
- Emitters are the typical water application device in many systems
- Can be “on-line” (usually with barb) or “in-line” (inserted into tubing by the tubing manufacturer)
- Various approaches are used to provide energy dissipation: long-path (“spaghetti tubing”), tortuous path (labyrinth), orifice, vortex,
- Some emitters have flushing, or continuous flushing features to help prevent clogging while still having small flow rates (some designs are very clever)
- Some emitters have pressure compensating features to provide a more constant flow rate over a range of operating pressures
- Some emitters are designed with multiple outlets



2. Line Source Tubing

- These are typically buried
- Single chamber with small orifices

- Double chamber with orifices between chambers and orifices to discharge water into the soil (acts something like a manifold to control pressures and provide greater uniformity)



- Can be removed and reused next year (typically 4-5 years life)
- Can be “disked up” and left in the field as chunks of plastic
- Porous or “leaky” pipe, made from old tires or new materials

3. *Micro-Sprayers*

- These are like small sprinklers, but may not overlap enough to wet the entire ground surface
- Sometimes referred to as “spitters”
- A “gray area” between micro and sprinkle irrigation – they have both precise application and aerial + soil distribution of water
- Larger wetted area per applicator, compared to non-spray emitters
- Less susceptible to clogging than most emitters

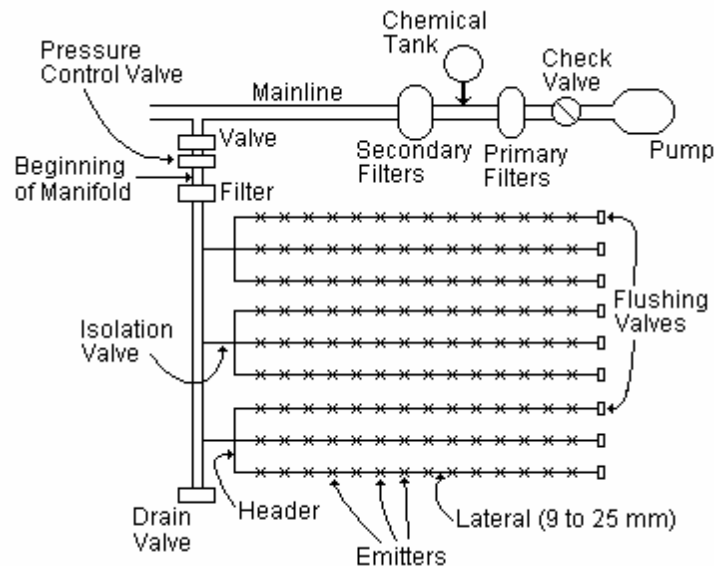


V. Types of Pipe Materials

- Laterals are usually polyethylene (PE)
- Laterals may be made from polybutylene (PB) or PVC
- Metal pipes are not used because of corrosion problems from injected chemicals
- Non-buried lateral tubing should be black to discourage growth of algae and other organic contaminants (don’t allow light to enter the tubing)
- Non-buried pipes preferably have ultraviolet light (UV) protection to prevent rapid deterioration from exposure to sunlight

VI. Typical Trickle System Layouts

- Chemical injection should be upstream of filters to prevent system clogging
- Chemical tank and valves are often plastic to avoid corrosion and freeze-up
- A check valve will help prevent contamination of the water supply
- Manifolds are often the basic operational subunits
- Valves for flushing at ends of manifolds and laterals are often manually operated
- Various mainline-manifold-header arrangements are possible



VII. Emitter Flow Rate versus Pressure

- The discharge equation for emitters is similar to that used for sprinkler nozzles, but the exponent on the head or pressure term is variable
- An exponent of $\frac{1}{2}$ corresponds to orifice flow, which is how some, but not all, emitters are designed
- The general emitter equation is:

$$q = K_d H^x \quad (329)$$

where q is the volumetric flow rate; K_d is the discharge coefficient; H is the head (or pressure); and x is the exponent

- Note that the value of K_d is different depending on whether units of head or pressure are used in the equation
- The exponent in the above equation is a function of the emitter design

- For purely turbulent orifice flow the exponent is $\frac{1}{2}$, assuming the pressure head is fully converted to velocity head
- Pressure compensating emitters have $x \leq \frac{1}{2}$. A fully pressure compensating emitter would have $x = 0$ (but these don't really exist)
- Long-path, laminar-flow emitters typically have $x \approx 0.7$ (if the flow were completely laminar, the exponent would be 1.0)
- Vortex-type emitters typically have $x \approx 0.4$

VIII. Emitter Design Objectives

- The two basic emitter design objectives, other than energy dissipation, are:
 1. Have a low value of the exponent, x
 2. Have flushing properties to prevent clogging
- The first objective provides for pressure compensating features, if the exponent is less than 0.5 (i.e. compensates better than a simple orifice)
- The first and second objectives tend to be conflicting, because the more pressure compensating the less ability to flush particles

IX. Field-Measured Uniformity

- To measure emission uniformity in the field you can use an equation equivalent to the Distribution Uniformity (DU), as applied to sprinkler systems:

$$EU' = 100 \left(\frac{q_n'}{q_a} \right) \quad (330)$$

where EU' is the field test emission uniformity; q_n' is the average discharge of the low $\frac{1}{4}$ emitters from the sampling; and q_a is the average discharge of all emitters sampled

- EU' should be at least 95% for properly designed and properly maintained trickle irrigation systems
- Note that it is impossible to calculate EU' based on field measurements if the system is being designed (hasn't been installed yet) – in this case there are other equations to approximate EU (recall the *design efficiency* for sprinkler systems)
- Most nonuniformity in micro irrigation systems is caused by: (1) emitter plugging, wear, and manufacturing variations; and, (2) nonuniform pressure distribution in pipes and hoses

X. Manufacturer's Coefficient of Variation

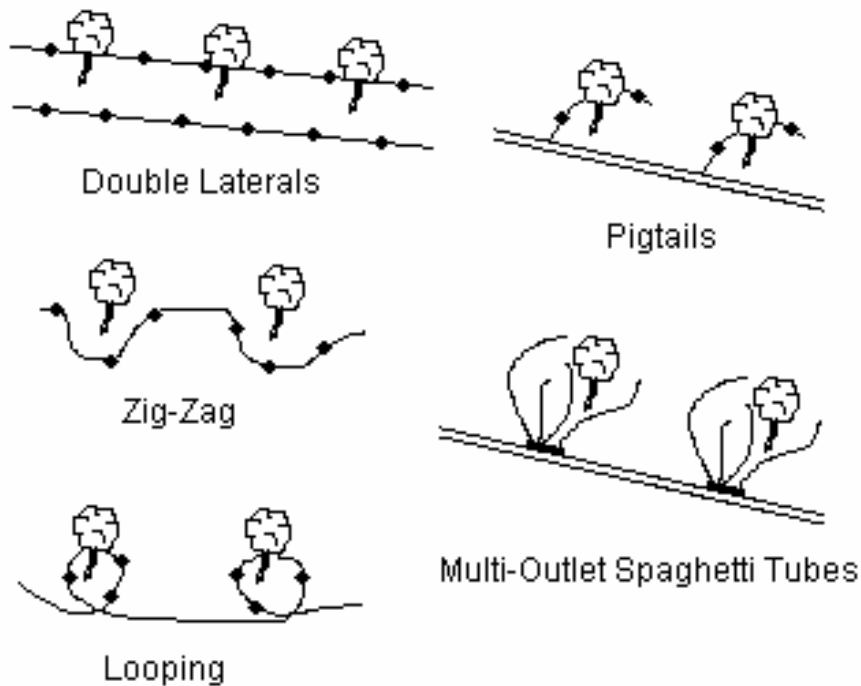
- Emitters of the same type and manufacture have variations in discharge (at the same operating pressure) due to small differences from manufacturing tolerances. Some variation is allowed in the interest of cost savings.
- The *manufacturer's coefficient of variation* is defined as:

$$v = \frac{s}{q_a} \quad (331)$$

where the standard deviation, s , is calculated from at least 50 samples (all at the same pressure) of the same emitter type and model; and the denominator is the average discharge of all emitters

XI. Emitter Layouts

- There are a number of configurations designed to increase the percent wetted area, and still be economical
- There are tradeoffs between flow per lateral and total length of pipe and tubing
- Below are some common emitter layouts



XII. Valves & Automation

- Valve automation can be accomplished with individual timers/devices, or with a central controller

1. *Volumetric Valves*

- Manually turned on
- Automatically turn off

2. *Sequential Operation*

- Manually turned on
- Automatic sequencing from low to high elevation

3. *Fully Automatic*

- Time-based: soil moisture sensors determine whether to turn the system on at a given time each day, then the system runs for fixed duration in each subunit
 - Volume-based: uses a flow meter to measure a specified volume delivered to a subunit, then turns water off to that subunit
 - Soil moisture-based: uses tensiometers, resistance blocks, or other device to determine when to irrigate and for how long
- Note that time-based systems may give varying application depths over time if the system flow rate changes due to clogging of filters
 - This can be partially corrected by using pressure compensating emitters
 - However, the use of a volume-based system with a flow meter may be best because the flow rate measurement also gives an indication about filter clogging