

Improving Irrigation Uniformity of Drip Systems on Sloped Fields

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Much of the strawberry and cane berry acreage along the central coast is located on hilly ground. As fields are planted during the fall, growers may want to consider design improvements that maximize the uniformity of their drip systems. Not only is high irrigation uniformity desirable for evenly applying water, but also for evenly distributing fertilizers and pesticides that are injected into the drip system.

Drip can potentially improve irrigation uniformity, but on steep fields, achieving a high uniformity can be challenging. An elevation change of 2.3 feet will cause a 1 pound per square inch (psi) change in pressure in a drip line. Drip tape on a 5% sloped field, would have a change in pressure of about 6 psi along a 300 foot distance. Assuming the drip tape was medium flow tape (0.32 gpm/100 ft), and the pressure at the manifold was 10 psi, then 25% more water would be applied at the lower end of the field compared to the top of the slope. The extra water applied at the lower end of the field may saturate the soil, which may promote soil borne root diseases, as well as increase the amount of fertilizer applied through the drip system.

Because the terrain of each ranch is unique, different solutions must be used to improve drip uniformity. A qualified irrigation system designer can help determine the most economical approach to managing slope effects on irrigation uniformity. The following paragraphs discuss some of the typical methods that a designer may use to increase drip uniformity if elevation varies among irrigation blocks, along the length of the beds, or along the manifold (submain).

Managing elevation change among irrigation blocks

The pressure of the mainline will vary among irrigation blocks located at different elevations relative to the pump or water source. If the block is located far above the water source, the pressure in the mainline may be low, and if the block is below the water source, then pressure in the mainline may be high. Irrigators need to assure that the blocks are adjusted to the same pressure during each irrigation in order to apply the same amount of water per hour. A minimal solution is to adjust the pressure using a gate valve (Figure 1). An accurate pressure gauge should be used to check the pressure of the manifold (submain) periodically during an irrigation in case the upstream pressure changes. As other irrigation blocks are opened and closed the pressure in the mainline frequently varies.

A remedy preferable is to add a pressure regulator after the gate valve. A pressure regulator can be preset to maintain the downstream pressure in the irrigation block independent of changes in the upstream pressure. Keep in mind that pressure regulators can only reduce pressure on the downstream side, so the upstream pressure must be maintained above the desired downstream pressure.

Pressure regulating valves combine pressure regulators with valves so that a gate valve is unnecessary (Figure 1D). Some regulators are preset to a downstream pressure and require no adjustment (Figure 1A and 1B) and other types need to be adjusted to the desired downstream pressure (Figure 1C and 1D). Pressure regulating valves, suitable for pipe of greater than a 3 inch diameter, usually use a pilot regulator to adjust the downstream pressure in the valve (Figure 1D). The use of the pilot minimizes pressure loss that would occur in the valve at high flow rates (> 100 gpm). Recently, several companies have begun marketing plastic pressure regulators for 2 to 4 inch diameter pipe (Figure 1D), which reduces the cost of these regulators relative to cost of steel and brass regulators.

Managing slope along the bed

Orienting beds with the contours of the slope can minimize elevation changes along the bed. Elevation changes should be minimized to less than 10 feet along a bed of a 300-foot length (3.3% slope), which equates to a 4.3 psi difference in pressure between the beginning and the end of the bed. Depending on the flow rate and diameter of the tape, the pressure gain at the bottom of the bed can be offset by a frictional loss of pressure caused by the water flowing against the inside wall of the tape. Frictional losses can be increased by using narrow diameter tape (5/8 inch) and high flow tape (> 0.5 gpm/100 ft). Locating the submain at the low end of the beds is not recommended because the frictional loss in pressure would add to the pressure loss caused by the increase in elevation.

Shortening the length of the beds can also minimize the elevation change along the beds but may be costly in terms of the extra hardware needed for additional submain components. Increasing the operating pressure of the block can minimize the elevation effects on uniformity because the variation in pressure becomes less relative to the average pressure of the block. However, higher operating pressures may require the use of thick walled tape (> 10 mil) to prevent the tape from bursting, and therefore would significantly add to the drip tape costs.

An additional approach to managing elevation change along the bed is to use pressure compensating tape, which is generally more expensive than non-pressure compensating tape. Pressure compensating tape minimizes the effects of pressure inside the drip line on the discharge rate of the emitters. However, before making the leap to pressure compensating tape, one should consider how well a particular brand of tape compensates for pressure (emitter discharge exponent), the variation in discharge among individual emitters (manufacturing coefficient of variation), and the filtration requirements of the emitters (filtration mesh). A small emitter discharge exponent (< 0.2) means the tape compensates better for pressure than a tape with a large emitter discharge exponent. A small manufacturing coefficient of variation means that difference in discharge between emitters is minimal ($< 3\%$ variation is recommended). Also, because the tape must operate under higher pressures than non-pressure compensating tape, a thick walled tape is required (usually > 8 mil) to resist bursting.

Managing slope along the manifold (submain)

Even with beds oriented along the contours of the terrain, elevation change along the submain can cause pressure to vary greatly between beds at the top and the bottom of a slope. Using small pressure regulators, beds of a similar elevation can be grouped together so that they all have the same pressure (Figure 3). Although a gate valve could be used to adjust the pressure of the group of beds, a preset pressure regulator that can handle flow rates of up to 10 to 20 gpm would automatically hold the downstream pressure independently of changes in upstream pressure (Figure 2B). Another approach would be to position pressure regulators in the submain at locations where the elevation changes by 10 to 15 feet. Again, a preset pressure regulator that fits on a 2 to 3 inch diameter submain would be appropriate for this application (Figure 2A).

Some irrigation designers have successfully used narrow polyethylene tubing (spaghetti tubing) to increase the frictional loss of pressure between the submain and the drip tape. As the pressure in the submain increases towards the bottom of the slope, narrower and/or longer polyethylene tubes are used to connect the submain to drip tape in order to bleed off pressure. The length of the polyethylene tube and the narrow diameter causes pressure loss as the water flows into the drip line.

Pressure compensating (PC) tape can also be used to manage elevation changes along the submain. The same considerations as discussed above should be made in choosing an appropriate PC tape for elevation changes along the submain. However, because pressure differences may be even greater along the submain than along the beds, the tape may need a thick wall to resist bursting under high pressures. For example, if the elevation change were 30 feet along the submain and the pressure of the highest bed was 10 psi, then the pressure of the lowest bed would be 23 psi.

Minimizing drain down on slopes

A common problem when drip systems are on sloped ground occurs after the irrigation ends and the remaining water in the submain and drip lines drains to the low end of the field, saturating the soil. If the slope of the field is oriented along the beds, then adding flush valves to the end of the drip lines can release trapped water (Figure 4). Flush valves can be purchased to close at specific pressures (usually between 2 and 6 psi). As the elevation change becomes greater, one should use valves that close at higher pressures (eg. > 5 psi)

A low pressure release valve can be used to release water trapped in the low end of the submain. The outlet of the low pressure release valve can be fitted with a hose so that water can be drained away from the block (preferably into a retention basin). Low pressure release valves can also be purchased with springs of different release pressures. For a 30 to 50 foot elevation change, the valve should open when the pressure at the end of the submain is below 10 psi in order to drain the lower half of the block.

Summary

Designing drip systems for operation on hilly ground can be challenging and the options for attaining good uniformity is highly dependent on the terrain. Fortunately, new types of components are available, such as pressure compensating tape, inexpensive pressure regulators, and flush valves, that can be used to improve uniformity. With the help of an irrigation designer, one should be able to find an economical solution to attain good irrigation uniformity on hilly land using drip.



Figure 1. A gate valve with a Schrader valve allows pressure to be adjusted and monitored in an irrigation block, but the valve must be adjusted manually to compensate for changes in upstream pressure.

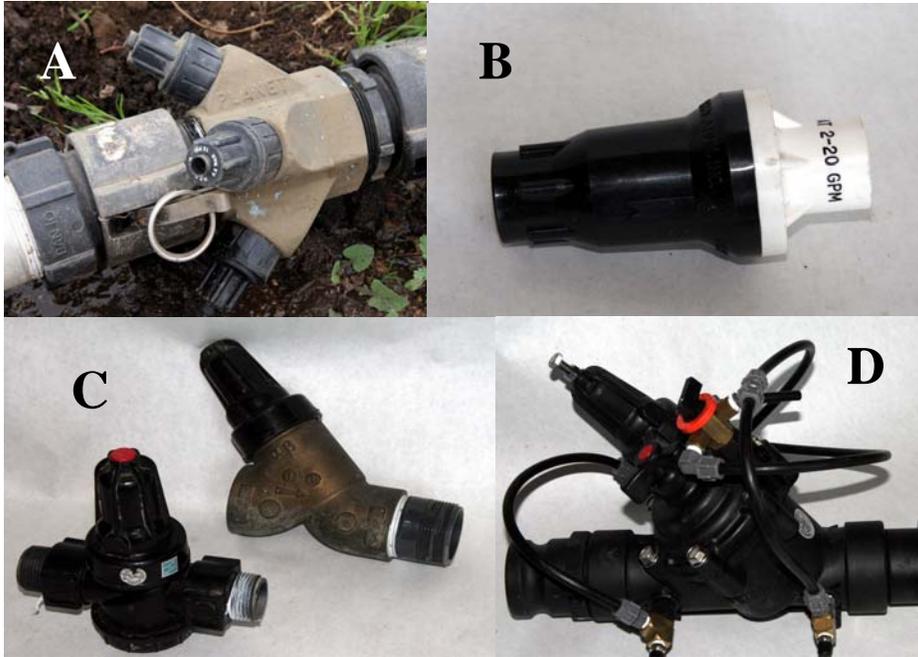


Figure 2. A brass pressure regulator preset for 12 psi can be used on 2 inch diameter pipe for flow rates up to 75 gpm (A), a plastic pressure regulator preset to 15 psi can be used on 1 inch diameter pipe and for flow rates from 2 to 20 gpm (B), adjustable plastic and brass pressure regulators for 1 inch and 1.5 inch diameter pipes, respectively (C), and a plastic pressure regulating valve with pilot for 2 inch diameter pipe (D).

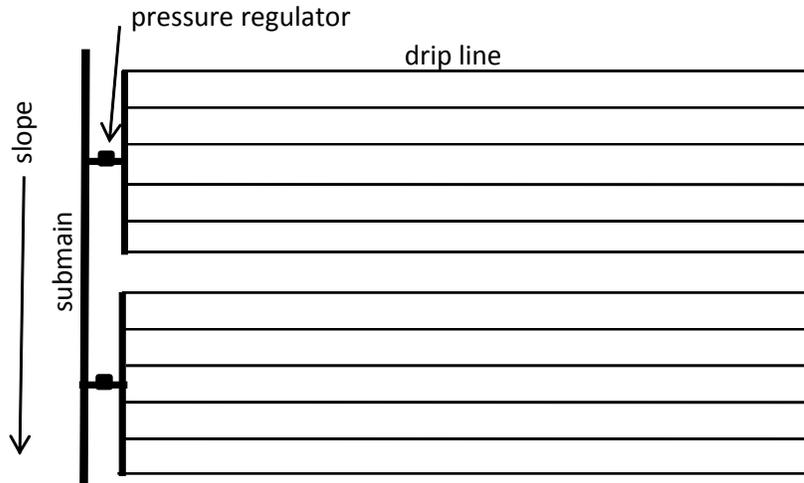


Figure 3. Use of preset pressure regulators on the submain to regulate pressure in groups of drip lines located at similar elevations.



Figure 4. Flush valves release water trapped in the end of drip lines after the irrigation ends.