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Fact Sheet 97-13

Subsurface Drip Irrigation

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Introduction

Irrigation consumed about 83 percent of the water used in Nevada in 1990 (Nevada Water Facts, 1992), amounting to approximately 3.3 million acre-feet. Approximately 1.8 million acre feet of the water withdrawn for irrigation purposes was used consumptively (Nevada Water Facts, 1992). Consumptive use is the quantity of water used and transpired by vegetation plus the amount evaporated from soil surfaces. The remaining 1.5 million acre-feet (45 percent) was lost to inefficiencies in the irrigation process. As Nevada's population grows, particularly in the urban areas, precious agricultural water supplies and use will come under increased scrutiny. Alternative irrigation methods are needed that will address the inefficiencies of traditional irrigation practices as well as help Nevada producers realize increased crop yields on unpredictable water supplies. Subsurface drip irrigation (SDI) is one of several viable alternatives for addressing these issues.

Subsurface drip irrigation is the slow frequent application of water to the soil profile through emitters placed along a delivery line placed beneath the soil surface. Although SDI is one of the oldest modern irrigation methods (House, 1920), relatively recent advances in plastics technology and SDI equipment have made it more affordable and long-lasting.

OPERATION OF SDI SYSTEMS

SDI systems are designed to apply small amounts of water on a frequent basis. The system should be operated often enough to avoid large swings in the moisture content of the soil. The goal is to maintain soil moisture content at a level which is optimal for plant growth and root development. Therefore, it is important that irrigation with SDI be scheduled using devices such as evaporation pans soil moisture measuring equipment, or weather stations as opposed to fixed schedules based on something other than crop needs.

BENEFITS OF SDI

Research has shown SDI has many benefits; a few of them are described below.

Water Application Efficiency and Uniformity

Water application efficiency is the ratio of the amount of water placed in the crop root zone and used by a crop to the total amount of water applied to the field. Properly managed SDI systems wet the root zone uniformly throughout the field while maintaining a dry soil surface thereby reducing water losses due to evaporation. A dry soil surface also reduces weed growth and allows implement traffic even during irrigation. Phene's and Hutmacher's (1992a) research has also shown that deep percolation losses and runoff can be reduced with SDI systems.

Water Use Efficiency

Water Use Efficiency (WUE) is crop yield per unit of applied water. WUE has several important implications related to agriculture sustainability, soil and water conservation, and alfalfa production in Nevada. These implications will become more important in the future as the competition for Nevada's agricultural water resources increases. On cotton, Phene et al. (1992b) found that out of eight irrigation methods SDI had the highest WUE. Lamm et al. (1992) studied subsurface drip irrigation in field corn and found that maximum yields were achieved at 75 percent of evapotranspiration (ET). Evapotranspiration is the combined loss of water by evaporation from the soil surface and by transpiring plants. Phene et al (1985) also found that tomato yields nearly doubled over conventional irrigation methods when SDI and proper fertilization practices were followed. Finally, Hutmacher et al. (1992) are presently conducting a five year study to evaluate the effectiveness of SDI versus furrow irrigation of alfalfa. In the first eighteen months of operation, 22 percent higher yields were achieved on the subsurface drip irrigated plots than on the furrow irrigated plots while using 6 percent less water. Subsequent years yields have been 26 to 35 percent higher in the SDI plots with similar water application rates.

Reduced Energy Consumption

SDI systems have the potential to operate at lower pressures than conventional pressurized irrigation systems. Manufacturers of SDI tape/tube products generally recommend operating pressures in the range of 8-20 psi. The actual operating pressure at the pump is higher than the tape/tube pressure since it accounts for pumping lift and friction losses in pipes and fittings. Depending on the field being irrigated, the system operating pressure can still be lower than conventional pressurized systems. An economic analysis conducted by Bosch et al. (1992) indicates low pressure subsurface systems have lower energy costs than center pivots because center pivots have higher pressure requirements. Center pivots also pump twice as much water per acre per day and have lower water application efficiencies.

DRAWBACKS OF SDI

System Costs

SDI systems are generally more expensive to install than other types of irrigation systems. Costs can range from $500 to $1500 on a per acre basis. Several parameters which significantly impact the expense of SDI systems are: degree of water filtration needed; expected life of the system; and lateral spacing. Sites with clean water may be able to get by with less elaborate, and consequently less expensive, filter systems than sites using dirtier water. Expected system life is highly dependent upon the operation, design, and ongoing maintenance of the system. Industry representatives indicate properly designed and maintained systems should last up to 15 years. Systems improperly designed, operated, and maintained are subject to plugging and root intrusion and will have a shorter life. Spacing of the laterals also affects the cost of the system. Lateral spacing is dependent upon the crop to be grown, soil chemistry, and soil texture. Systems with wider lateral spacing are less costly to install and maintain than systems with narrower spacing.

Germination

Seed germination with SDI systems is highly site specific and may or may not be possible depending on seed placement, soil texture, lateral spacing, and emitter output. For most crops grown in Nevada an alternate irrigation system will be needed for germination.

Salt Management

Nevada's desert soils have a high concentration of soil salts. SDI systems normally concentrate salt at the outer edges of the wetted soil volume. What this means is that salt concentrations will be greatest near the soil surface, in between rows of tape/tubes, or near the bottom of the wetted soil volume. Producers will need to keep this in mind and devise strategies to deal with excess concentrations of soil salts.

COMPONENTS OF A SDI SYSTEM

Laterals

The key component of a SDI system is the lateral which is placed in the crop root zone and delivers water to the crop (Figure 1). Tapes and tubes are the two products available for use as laterals. Tape products are thinner than tubing and range from 4 to 20 mil in thickness. Tapes generally cost less than tubes and are commonly used in annual installations. Tubes range from 20 to 45 mil thickness and consequently are more expensive. Tubes are commonly used in permanent installations due to their longer expected life.

Water is conveyed through the lateral and into the soil profile through emitters which are located within the lateral. Emitters come in various shapes and sizes and can be fabricated as orifices directly into the tape during manufacturing, or can be manufactured as a separate unit and either cemented or inserted into the tape/tube during the manufacturing process. Neither method is necessarily better than the other; which one to use depends on the intended application, as well as considerations such as price, plugging, reliability, and expected life. The diameter of the tape/tube plays an important role in how far the laterals can efficiently convey water.

Emitter flow rates are commonly specified in water output per length of lateral (e.g. gpm per 100 feet of tape/tube), or water output per emitter (e.g. gph per emitter). Among other factors, emitter flow should be selected based on soil characteristics, water availability and quality, and plant needs. There are additional emitter and tape/tube properties such as pressure-flow characteristics, distribution uniformity, and coefficient of manufacturing variation, which must be considered in the irrigation system design phase. SDI design is complicated, growers considering SDI should discuss these properties with qualified designers.

Filtration

Water filtration is extremely important and plays a major role in determining the expected life of a SDI system. Filtration removes suspended particles from the water which otherwise could plug the laterals. All SDI systems require filtration. The extent of the filtration required depends on the water's chemical and physical composition. Generally speaking, surface water requires a greater degree of filtration than groundwater. Relatively clean water may get by with a sock or disk filter, while dirtier water may require media filters. Filters must be matched to handle the flow rate of the irrigation system to insure proper filtration.

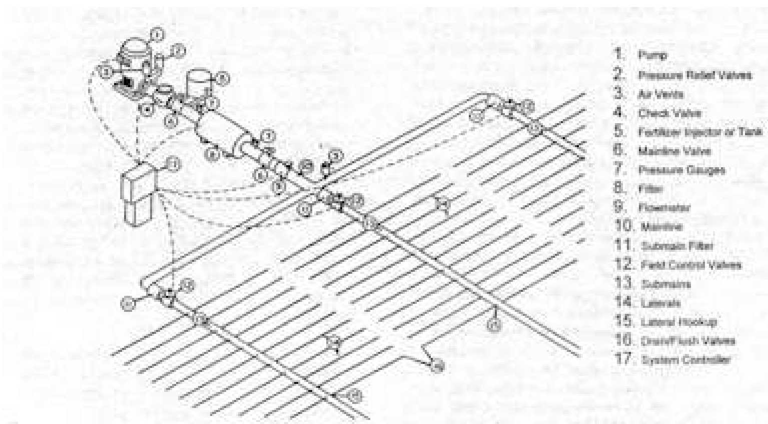

Figure 1. Typical Drip System Layout. T-Systems International, Inc. 1992.

Chemical Injection Capabilities

Chemical injection capabilities are important to SDI systems. First, chemicals must be injected periodically to keep the system operating as designed. Depending on the quality of the irrigation water, injection of either acid or chlorine may be required on a continuous or intermittent basis. Acidifying the water lowers its pH and prevents chemical precipitates from forming and plugging the tape/tubing. Chlorine may also be required to prevent algae and bacterial growth in the system. Chemical injectors may also be used to inject fertilizer and/or soil activated pesticides directly into the root zone throughout an entire field. Research has shown nutrients "spoon fed" into the root zone increases the effectiveness of the nutrient (Phene et al., 1988). This results in lower fertilizer application rates which also reduces the potential for offsite nutrient losses.

Additional System Components

- Flow Meters: Meters are needed to monitor the quantity of water being applied to a field. If the flow rate changes from one time period to another, or from the design flow rate it may be an indication of problems such as plugging or worn pump vanes.
- Pressure Gauges: Gauges are needed to insure the system is operating at the designed pressure for the tape/tubing used. Additionally, gauges are used to determine the operational state of the irrigation system. If the pressure changes from the normal operating system pressure and the operator hasn't made any changes in the system settings there may be a problem such as those listed above.
- System controllers: Another benefit of SDI is the flexibility in the amount of automation which can be used to operate the system. If the producer so desires, the system can be turned on and off manually. Producers desiring more automation can choose from a wide spectrum depending on their comfort level. System controllers can turn the system on and off several times a day, or on any day of the week; or the system can be automated to the degree that irrigation is automatically scheduled based on real time weather information. Additionally, system operating parameters such as flow rates, pressure, water pH, fertilizer injection rates, etc. can be monitored and the status noted anytime through the use of a computer and modem. Irrigation system settings can be changed onsite or remotely through the use of a computer.

Some of the other needed components are pressure and vacuum relief valves, check valves, backflow prevention valves, field control valves, and pressure regulators.

CONCLUSION

The challenges and opportunities of using SDI are many. SDI has the proven potential to increase crop yield, increase soil and water conservation, improve crop quality, and reduce environmental degradation. However, the benefits cannot be achieved without a change in our mindset about efficient irrigation and a willingness to adapt and learn new technologies. As agricultural water resources become increasingly scarce in the future SDI may present a partial solution to some of the challenges associated with irrigated agriculture in Nevada.

Use of product names within this paper does not imply endorsement of any kind by the University of Nevada, Reno or the authors.

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