
Low Elevation Spray Application (LESA) System

Agricultural Water Conservation Practices

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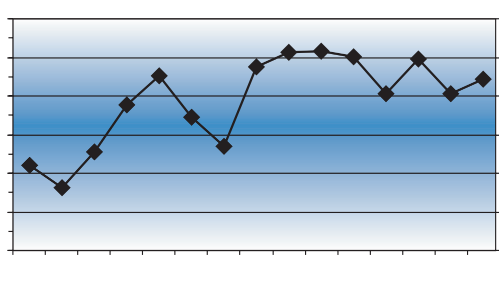
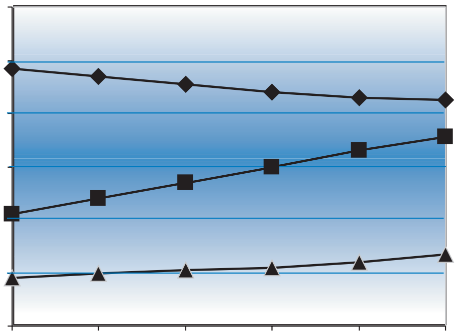
Introduction

According to the 2002 Texas State Water Plan, agricultural irrigation water demand is expected to decline by 12% in the next fifty years. It will, however, continue to be the largest water user in the State, accounting for 42% of the State's total projected water demand. Between 1986 and 2000, about 7 to 10 million acre-feet of water was used for irrigation per year. Eighty percent of agricultural water use in Texas comes from groundwater supplies, and existing groundwater supply is expected to decrease 18% by 2050. Available supply from the Texas portion of the Ogallala Aquifer, a major source of irrigation water for the heavily agricultural Panhandle/South Plains region, is expected to decrease 24% by 2050. Twelve counties in Texas are among the top 100 U.S. counties in farm product sales. Most of these counties are heavily dependent on irrigation and more than 30% of their income is from farming. Texas' economy relies on the continued viability of agriculture, which depends on reliable water sources. Conservation is an important part of meeting agricultural water demand in the next fifty years. On-farm water use can be reduced substantially without decreasing productivity through improved irrigation technologies and efficient water management practices.

Accurate water measurement and soil moisture monitoring are key components of efficient on-farm water management practices. Irrigation flow meters can be used to help calculate the efficiency of irrigation systems, identify water loss from leaks in conveyance systems, and to accurately apply only the necessary amount of water based on soil moisture levels and weather conditions. Soil moisture monitoring is used in conjunction with weather data and crop evapotransporation requirements to schedule irrigation. Fields should be designed for efficient water use by grading land with laser equipment, creating furrow dikes to conserve rainwater, and by retaining soil moisture through conservation tillage.



There are three basic types of irrigation: surface (gravity), sprinkler, and drip irrigation. Using surge flow valves and reusing tailwater can increase water use efficiency of gravity irrigation systems. Modifying older high pressure sprinkler systems using the LEPA or LESA methods (see page 8) can increase sprinkler water use efficiency by 20 to 40%. Drip irrigation is a very water efficient method of irrigation that can be effective with certain crops and on uneven terrain. This brochure outlines each of these agricultural water-efficiency measures and explains how they can help save water, energy and money, and possibly even increase crop yields.



Agricultural Irrigation Scheduling

Irrigation scheduling involves managing the soil reservoir so that water is available when the plants need it. Soil moisture and weather monitoring are used to determine when to irrigate, and soil capacity and crop type are used to determine how much water should be applied during irrigation.

Soil moisture monitoring

Regardless of the irrigation system used, scheduling irrigation should be based on the crop's water needs. Crop water need is often assessed by monitoring soil moisture. There are many ways to measure soil moisture, each method having its own advantages and disadvantages, and varying degrees of accuracy. The most obvious and common method of soil moisture monitoring is to observe the soil **feel and appearance** at various soil depths within the crop root zone. The Natural Resource Conservation Service maintains a web site featuring photographs of soil feel and appearance for various levels of plant-available water contents in the four major soil textures from sand to clay (http://nmp.tamu.edu/estimatingsoilmoisture.pdf). Several sensors are available to measure soil water tension rather than soil water content. This is appropriate because soil water tension relates to how easily a crop may take up water from the soil. **Gypsum blocks** are widely used and inexpensive devices that measure soil water tension through electrical conductivity. However, they require individual calibration, they are not accurate in very wet, or saline soil, readings are affected by soil temperature changes and fertilizer addition (which changes soil conductivity), and calibration gradually changes with time. New blocks may need to be installed every year. **Granular matrix sensors** provide more stable calibration and more accurate tension measurements in wet soil. Equipment is available for recording the readings from granular matrix sensors and plotting them over time (http://www.cropinfo.net/OtherReports/HansenIA2000.htm). **Tensiometers** also measure soil water tension. Unlike gypsum blocks, they are reusable, and do not require calibration. However, they do not work well in coarse sand and some clay soils. They fail to read at higher tensions associated with drier soils, even though many crops still do well at those water contents. Regular maintenance is required throughout the crop season to purge air that has entered the tensiometer. Tensiometers are most commonly used with vegetable crops. **Capacitance or frequency domain (FD) probes** estimate soil moisture by measuring soil electrical properties that are related to water content. They can be read immediately, but are affected by salinity, soil texture, and small scale variability in soil moisture. Some capacitance probes can be used in an access tube, while others are made to be buried or have stainless steel probe rods that can be inserted into the soil. They need to calibrated before use. All soil moisture sensors except the neutron probe require excellent contact with the soil and will not give accurate readings if there are air pockets near the probes or access tube walls. The **Neutron probe** and the **gravimetric method** (calculating moisture as a percentage of soil weight) are the two most standard methods to obtain accurate soil moisture data. Like the capacitance sensors, the neutron probe must be calibrated for the particular soil in which it is used. However, access tube installation is much less critical with the neutron probe. The neutron probe requires training in radiation safety and a license to handle the low-level radioactive neutron source. It also requires the presence of a licensed operator in the field at all times during use. These factors combine to make the neutron probe expensive to use. For these reasons, neutron probes are usually not practical for individual farmers, but they are used by consultants and government agencies for irrigation scheduling and soil moisture monitoring. The High Plains Underground Water Conservation District No. 1 and the USDA-NRCS use the neutron probe to conduct an annual survey of pre-plant soil moisture conditions at 400 permanent monitoring sites located within the district's 15 county service area. The district publishes maps illustrating soil moisture availability and deficits for three-foot and five-foot levels of the soil profile. In addition, maps of precipitation data are also published monthly during the growing season.[1] The gravimetric method does not require expensive equipment, but is time consuming both for acquiring soil samples in the field and for drying and weighing the samples. Although they do not measure soil water content or tension, **pressure bombs** and **infared thermometry** are commonly used research methods of assessing plant water status. They are not commonly used by irrigation farmers, although the pressure bomb is sometimes used for scheduling tree crop irrigations in California.

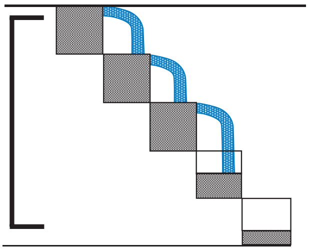
Weather Monitoring

Temperature, rainfall, humidity and crop evapotransporation (ET) data should be collected to determine efficient irrigation scheduling. ET is the sum of evaporation (water lost outside of the plant) and transpiration (water lost through the plant itself). Weather stations or networks often collect weather and ET data, which is made available to irrigators. The Texas A&M University Agricultural Program website (http://texaset.tamu.edu) contains weather information, ET data, and crop watering recommendations. Weather information and ET data gathered from stations should be confirmed by monitoring soil moisture changes and rainfall as it may not accurately reflect on-farm conditions. Irrigation guides may also be available from local water districts. Irrigation scheduling software programs can be used to control and monitor water application. These programs can be linked directly to an irrigation system's flow-control valve and connected with ET data from the internet so that water applications can be continually adjusted to weather and soil conditions.
The Texas A&M University Agricultural Program has irrigation scheduling software programs available free of charge at http://achilleus.tamu.edu/software/software.asp.

Soil Capacity

Soil acts as a water reservoir between irrigations or rains. Soil is also a nutrient reservoir, and it mechanically supports and stabilizes plants. Each soil type has a different capability to hold moisture based on soil depth, soil texture (ratios of various soil particle sizes), soil structure (soil porosity) and soil water tension. A combination of these elements determines the amount of water available to the plant. Soil type may vary within the root zone, so it is important to know crop root depth and the soil type throughout the root zone. Soil surveys by county are available at local NRCS offices (http://www.tx.nrcs.usda.gov/personnel/map5zone.htm). These publications contain information about local soil types, local soil permeability and available water capacity based on soil type. The table below estimates available water for various soil textures, including a margin of error of up to 25%. Each foot of soil in the root zone must be filled to water capacity (field capacity) before the next lower zone can be filled as shown in the figure below.

Soil Texture	Inches of Water Available per Foot of Soil
Coarse Sand	.50
Fine Sand	.75
Loamy Sand	1.00
Sandy loam	1.25
Loam	1.50-2.00
Clay or silt loam	1.75-2.50
Clay	2.0-2.4

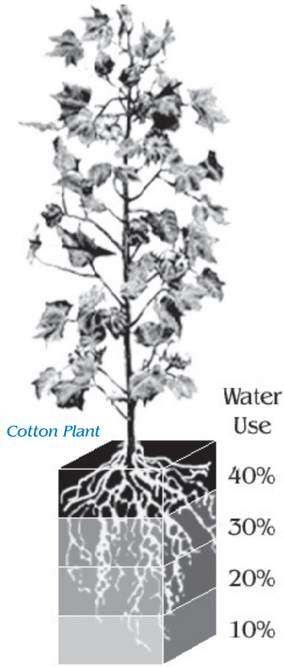


Source: *Ag-Irrigation Management* *(Irrigation Training and Research Center, 2000)*

Crop Type

Plants differ in their ability to withdraw water from soils, their water use rate, and their ability to withstand soil water stress. When the moisture content in the soil declines to a certain point, plants begin to irreversibly wilt. This point is called the permanent wilting point (PWP) and is measured by soil water tension. Plant available water (PAW) is expressed as the amount of water held between field capacity (FC) and the PWP (FC-PWP=PAW). Each crop and/or crop variety will have a different PWP. PAW must be determined for the whole root zone. As shown in the table on page 6, different crops have different rooting depths. Water salinity may also influence PAW. A farmer should allow the plants to deplete a pre-selected percentage of the PAW before irrigating again. This percentage is called the managed allowable depletion (MAD), and may change depending on growth stage (e.g., cotton may need to be stressed at certain growth stages to maximize yields or crop quality). Soil moisture monitoring throughout the root zone should be used to determine the exact amount of water needed to manage PAW. Plants take 40% of the water they use from the top 25% of the root zone (see figure, page 6), so over-filling the soil beyond field capacity in the bottom 25% of the root zone will cause deep percolation rather than increasing yields. Crop rooting depth will be dependent on local conditions such as soil salinity, changes in soil type, compaction, shallow water tables, and fertility. Rooting depth is less in clay soils than in sandy soils.

Crop	Approximate Root Depth (ft)
Alfalfa	4-6
Citrus	2-5
Cabbage	1.5 - 3
Corn	2.5-4
Cotton	3-4
Grass	3-4
Melons	2-3
Oats	3-5
Onions	1.5
Peanuts	2-2.5
Potatoes	2-3
Sorghum	2-3
Soybeans	2-3
Sugar beet	2-4
Sugarcane	4-6
Tomatoes	2-4
Turf grass	.5 - 2.5
Wheat	3-4



Source: Ag-Irrigation Management (Irrigation Training and Research Center, 2000) and Texas Agricultural Extension Service

Water Conservation and Farm Management

Better management practices can be as effective as new technology in increasing water-use efficiency. Using the techniques mentioned above, farmers can determine how much water is needed to maximize productivity while minimizing water waste. After the field capacity of the soil in the root zone has been reached, the crops cannot utilize the excess water, and may be stressed from reduced oxygen levels of saturated soil. Furthermore, the water, the energy used to pump that water, and the money spent on energy costs will be wasted.

Preparing Fields for Efficient Water Use

Laser Leveling

Laser-controlled land leveling equipment grades fields to contour the land for different irrigation practices. With sprinkler systems, a perfectly level field conserves water by reducing runoff, allowing uniform distribution of water. Furrow irrigation systems need a slight but uniform slope to use water most efficiently. Laser leveling can reduce water use by 20-30% and increase crop yields by 10-20%.

Furrow Diking


LEPA irrigation drop tube and furrow diking

Furrow diking conserves water by capturing precipitation or irrigation water in small earthen dams in the furrows. Water held between the dams can slowly infiltrate into the soil, increasing soil moisture and reducing or eliminating runoff. Furrow dikes can benefit dryland farmers, sprinkler irrigators and furrow irrigators who water alternate rows. Dikes should be made large enough to hold runoff during intense thunderstorms when the soil is not able to immediately absorb the intensity of rainfall. If the field has a slope, furrow diking is especially important to reduce excessive runoff. It is also an important part of LEPA irrigation systems, especially on less permeable soils. Water is applied directly to furrows by drop lines from the sprinklers.

Conservation Tillage

Conservation tillage helps preserve soil moisture by leaving at least 30% of the soil surface covered with crop stubble, thereby decreasing wind and water erosion. The crop stubble layer reduces evaporation in the soil profile by one-half compared to bare soil. Conservation tillage can also reduce pollution caused by runoff and enrich the soil with organic matter.

Tailwater Reuse

Tailwater, or runoff water, should be minimized as much as possible through soil monitoring and irrigation methods that reduce runoff, such as surge flow irrigation and furrow diking. However, if field runoff is present, it should be captured at the lowest end of gravity-irrigated rows and reused. Reuse of runoff water works best with laser leveling, and is effective with soils that have high water holding capacity. It is not recommended for areas where soils contain high concentrations of salt, and it may spread chemicals, diseases and weed seeds.

Efficient Irrigation Systems

LEPA (Low Energy Precision Application) and LESA (Low Elevation Spray Application)

LESA irrigation systems distribute water directly to the furrow at very low pressure (6-10 psi) through sprinklers positioned 12-18 inches above ground level. Conventional high pressure impact sprinklers are positioned 5-7 ft. above the ground, so they are very susceptible to spray evaporation and to wind-drift, causing high water loss and uneven water distribution. LESA systems apply water in streams rather than fine mists to eliminate wind-drift and to reduce spray evaporation, deep percolation and under watering. LEPA irrigation systems further reduce evaporation by applying water in bubble patterns, or by using drag hoses or drag socks to deliver water directly to the furrow. LEPA and LESA systems concentrate water on a smaller area and increase the water application rate on the area covered. Therefore, the application rate must be monitored closely to follow the soil intake curve, and furrow diking should be used to prevent runoff. In addition to water savings, these irrigation systems use much less energy (at least 30% less than conventional systems), which reduces fuel consumption and operating costs. Other advantages include reduced disease problems due to less wetting of foliage, and easier application of chemicals. Both lateral move (side roll) and center pivot systems can be readily converted to LEPA irrigation. Variable flow nozzles adjust flow from a computer to match microclimate conditions. Correct management of a LEPA system is essential to realize potential water savings. Farmers who replace older irrigation systems with LEPA sprinklers should adjust their management practices so that they do not continue to use excess water. If the pivot system does not have a digital control box showing the amount of water applied, meters should be installed or readings from portable meters should be requested from the local water district to accurately determine how much water is being applied. A center pivot evaluation spreadsheet designed to help farmers determine the efficiency of their pivot system can be downloaded from http://www.twdb.state.tx.us/assistance/conservation/eval.htm. When managed correctly, LEPA irrigation is 20-40% more efficient than typical impact sprinklers and furrow irrigation. While LEPA systems can be costly, this expense can be offset in 5 to 7 years through reduced energy savings of 35-50%, labor cost reduction of as much as 75%, and increased crop yields.[1]

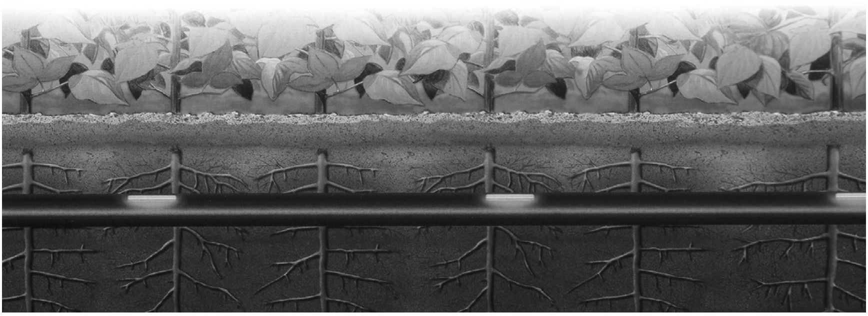
Surge Flow

Surge flow irrigation is a type of furrow irrigation that applies surges of water intermittently rather than in a continuous stream. These surges alternate between two sets of furrows for a fixed amount of time. The alternate wetting and "resting" time for each surge slows down the intake rate of the wet furrow and produces a smoother and hydraulically improved surface. By doing so, the next surge travels more rapidly down the wet furrow until it reaches a dry furrow. Surge irrigation provides more uniform water distribution, limits deep percolation, and can reduce tailwater runoff. Water infiltration varies substantially based on the type of soil, soil compaction, and soil preparation. Surge flow does not work well on compacted soils, so it is more effective during pre-plant irrigation and the first seasonal irrigation following cultivation. Surge flow can cut water losses by up to 30% in clay soils and can save more than 35% of energy costs compared to simple furrow irrigation. Savings in energy and pumping costs can pay for the cost of surge irrigation valves within two years.[1] Monitoring soil moisture is important for establishing on-off cycles for surge irrigation, and cycle length should be adjusted according to soil type. To accurately determine how much water is being applied, meters should be installed or readings from portable meters should be requested from the local water district. Surge irrigation increases fertilizer application efficiency and lowers salt loading by reducing deep percolation. It may not, however, improve yields when used on short level furrows where irrigation is relatively efficient. Using a computer program, some surge valves allow irrigators to adjust the valve controller for individual farm characteristics such as soil type, moisture content, slope, furrow size, infiltration rate and compaction.

Drip Irrigation

Drip irrigation applies small amounts of water frequently to the soil area surrounding plant roots through flexible tubing with built-in or attached emitters. Subsurface drip irrigation (SDI) delivers water underground directly to roots. Since water is applied directly to individual plant roots, SDI minimizes or eliminates evaporation, provides a uniform application of water to all crop plants, and applies chemicals more efficiently. Drip irrigation also reduces plant stress and increases crop yield. A carefully managed amount of water is applied, thereby avoiding deep percolation and runoff, while reducing salt accumulation. Since a constant level of moisture is maintained around the root zone, with less surface moisture present in between rows, weed growth is reduced. Water contact with crop leaves and fruit is also minimized, making conditions less favorable for disease. Drip systems reduce farm operation and maintenance costs through energy savings and automation. Also, drip systems are the only type of irrigation that can use water efficiently on steep slopes, odd-shaped areas, and problem soils.

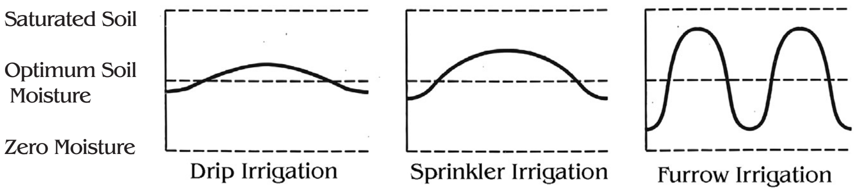
Subsurface drip irrigation has allowed a Lubbock County producer to increase his crop yield from 650 pounds of cotton per acre (about 1.3 bales) to 1,200 pounds of cotton per acre (about 2.5 bales).[1] Research conducted by the Texas Agricultural Extension Center in Starr County found that drip irrigation under plastic mulch produced a 60% higher melon yield with only 33% of the water and 40% of the nitrogen required by a furrow irrigated field. In addition, the melons matured faster, so they could be harvested earlier.



Subsurface drip irrigation

Although drip systems are very efficient, they do have some drawbacks. Because they may clog and are susceptible to damage by rodents, insects, and sedimentation, they must be checked regularly. A good filtration system is essential for proper performance of a drip system. Hard water should be treated to discourage mineral build-up. New systems are expensive, and must be designed to suit crops and local soil and climate conditions. A reliable, continuous water supply is necessary to run a drip system, and proper irrigation management and furrow shaping is necessary to prevent salt build-up. Rotating crops with different spacing requirements may be problematic after a drip system is installed. Drip irrigation may not be practical for closely spaced crops such as rice or wheat. If drip tapes are used, they are typically placed 10″ below the surface. This may cause some difficulty in germinating seed without rainfall. Disposing of used tape may also be a problem. Selecting a small test plot area is a relatively inexpensive way to experiment with drip irrigation.

Comparison between Irrigation Systems



Relative moisture varies the most in furrow irrigation and the least in drip irrigation systems.

Irrigation System	Range of Application Efficiency (percent)
Drip Irrigation	90-98%
LEPA Center Pivots	90-95%
LESA Center Pivots	80-90%
Surge Valves with Furrow Application	50-70%
Furrow with Open Ditch	40-60%

Source: High Plains Underground Water Conservation District #1, Lubbock, TX.

Canal and Conveyance System Management

Lining canals with concrete or other liners reduces water loss through seepage by 10-30%. Evaporation in canals can be reduced if irrigation districts provide water on demand rather than keeping the canals continuously filled. Using underground conveyance systems eliminates costly evaporation and deep percolation.

Conclusion

Using the methods outlined in this brochure will not only conserve water, but will preserve water quality, reduce or eliminate drainage problems, conserve energy, often increase production, and save money. The stress of droughts, higher expenses and low commodity prices will continue to make efficient water management practices a necessary tool for farmers who wish to remain competitive in today’s market. Efficient agricultural water conservation practices are essential to ensure the viability of Texas’ agricultural industry.

This brochure was developed by the Texas Water Development Board. Some reference material was adapted from "Handbook of Water Use and Conservation" by Amy Vickers (WaterPlow Press, 2001) and "Ag-Irrigation Management" (Irrigation Training and Research Center, 2000). [1]Additional information was provided by High Plains Underground Water Conservation District #1, Lubbock, TX and the Texas Agricultural Extension Service.

www.twdb.state.tx.us/assistance/conservation/agricons.htm

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For Today and Tomorrow

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