Improving Water Application Efficiency

- To improve application efficiency, irrigation systems should be evaluated for the ability to limit the following common water losses: evaporation from the soil and plant surfaces, runoff from the target site, and deep percolation below the root zone.
- Regular irrigation system maintenance along with proper cultural and management practices can help to improve the overall efficiency of water use on your farm.
- Low pressure adaptations to traditional sprinkler systems can improve application efficiency.

Water Application Efficiency

Water application efficiency describes how effective the irrigation system is in storing water in the crop root zone. More specifically, it is a measure of the fraction of the total volume of water delivered to the field that is stored in the root zone to meet crop evapotranspiration (ET) needs.

Mechanisms of Water Losses

The three biggest losses from irrigation applications include:[1]

- Evaporation from the soil and plant surfaces
- Runoff from the target site
- Deep percolation below the root zone

Irrigation water can also be lost due to evaporation of droplets in the air (especially with very fine droplet sizes) and wind drift.[2] Figure 1 depicts the various mechanisms by which water from an irrigation application can be lost.

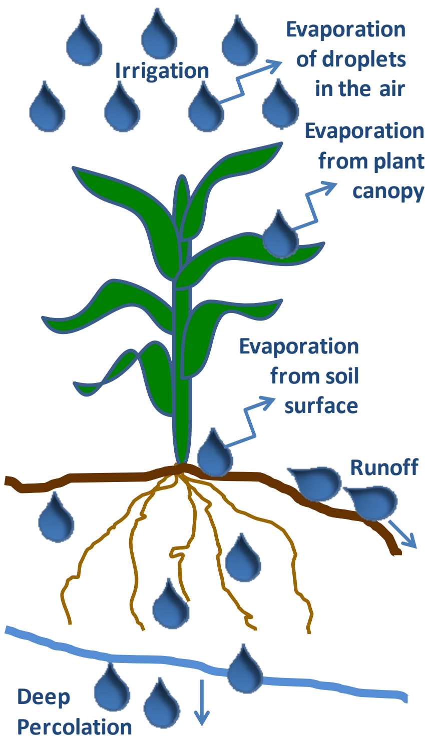

Figure 1. Mechanisms of water losses: evaporation of droplets in the air, evaporation from the plant canopy, evaporation from the soil surface, runoff, and deep percolation.

Each irrigation system should be evaluated for its ability to limit these three losses while applying water uniformly. Refer to Table 1 for potential application efficiencies of some common irrigation systems.

Improving Application Efficiency

Equipment Maintenance: Irrigation systems should be periodically inspected and properly maintained. Application uniformity should also be measured. For example, a detached or malfunctioning sprinkler nozzle could lead to over-irrigation resulting in excessive runoff and percolation below the root zone or dry patches in the field.

Reduce the Frequency of Irrigations: With some types of spray irrigation equipment, application efficiency can be reduced as application frequency increases. With every application, a percentage of the water applied will evaporate from the wet soil and plant surfaces. The rate of evaporation from the crop canopy will depend on climate demand, time available for evaporation to occur, and the surface area of the droplets.

Net canopy evaporation is considered the greatest evaporative loss from most sprinkler or spray technologies.[1] Researchers in Texas observed a 3% evaporative loss (0.03 inches) from the plant canopy with a spray head sprinkler and an 8% loss (0.08 inches) with a low-angle impact sprinkler following a 1-inch application.[2,3] The cumulative loss of water is exacerbated when the canopy is more frequently wetted and allowed to evaporate between applications as opposed to applying the same amount of water in fewer applications. For example, if two applications of 0.5 inches each were applied, the 0.08 inches could evaporate from the plant canopy twice, potentially amounting to 0.16 inches of irrigation water lost due to plant canopy evaporation.

Irrigation Scheduling: Scheduling irrigations based on soil moisture estimates or measurements can improve the overall efficiency of water use on your farm. Soil moisture levels can be tracked with soil sensors and/or weather-based crop ET estimates to determine when and how much irrigation is needed.

Water Measurement: Consider installing an irrigation flow meter to monitor the total volume of water pumped. Water measurement data can be helpful with determining overall irrigation system efficiency, monitoring system performance, detecting well problems, monitoring pumping plant performance, and simplifying completion of annual water use reports.

Improving Water Application Efficiency

Residue Management: Conservation tillage practices such as no-till and strip tillage have been shown to improve soil water holding capacity, water infiltration rates, soil moisture retention, and reduce runoff over conventional tillage.[4,5]

Sprinkler Irrigation Systems

Common water losses during sprinkler irrigation include: wind drift and evaporation of droplets in the air, evaporation from the crop canopy, and evaporation from the soil surface.[2] Water losses due to wind drift and evaporation from the air can be minimized with the use of lower-pressure systems that produce larger droplet sizes and by applying irrigation when temperatures and wind speeds are low. Evaporation from plant surfaces can be minimized as spray heads are moved closer to the soil surface, resulting in less wetting of the crop canopy.

Low pressure adaptations to traditional sprinkler systems include: LESA (low elevation, spray application), MESA (medium elevation, spray application), LPIC (low pressure, in-canopy), and LEPA (low energy, precision application). Water runoff can be an issue with these systems if application rates are not matched to soil intake rates. Cultural practices such as furrow diking can help minimize losses due to runoff.

Furrow Irrigation Systems

Furrow irrigation has one of the lowest application efficiencies among irrigation methods. Water losses during furrow irrigation include: runoff, evaporation from water in the furrow, evaporation from the soil surface, and percolation below the root zone. With surface irrigation, it is important to irrigate the entire field as quickly as possible. Furrows that are too long may result in deep percolation at the upstream end of the furrow by the time the downstream end is adequately watered.

Strategies for improving furrow application efficiency include: recovery and reuse of runoff water (tailwater), irrigating every other furrow, and surge irrigation. With surge irrigation, a surge valve is used to alternately send pulses of water down the furrow during advance cycles. Alternating wetting and drying allows soil particles in the bottom of the furrow to settle and may reduce the intake rate of the soil, which may help water advance down the furrow faster. Once water reaches the end of the furrow, pulses of water are sent down the furrow during soak cycles.

Microirrigation Systems

Microirrigation systems such as surface and subsurface drip are low pressure systems with the potential to deliver water at very high efficiencies if properly designed, maintained, and managed. These systems tend to have the highest initial investment costs and management requirements compared to other types of irrigation systems but can also have the highest application efficiencies and crop water productivity, especially under limited water situations.[2,6,7] Drip systems should be inspected regularly for the best performance. Water filtration is extremely important to the long-term viability of these types of systems, otherwise emitter clogging can occur within a few years.

Table 1. Potential application efficiencies (AE) for well-designed and well-managed irrigation systems

Irrigation system		Potential AE (%)
Sprinkler irrigation systems	LEPA	80-90
	Linear move	75-85
	Center pivot	75-85
Surface irrigation systems	Furrow (conventional)	45-65
	Furrow (surge)	55-75
	Furrow (with tailwater reuse)	60-80
Microirrigation systems	Microspray	85-90
	Subsurface drip	>95
	Surface drip	85-95

Table modified from: Irmak, S., et al. 2011. Irrigation efficiency and uniformity and crop water use efficiency. Publication EC732. University of Nebraska-Lincoln Extension.

Variable Rate Irrigation

Field characteristics such as soil type and slope are not always uniform. Variable rate irrigation (VRI) uses Global Positioning Systems (GPS) and Geographic Information Systems (GIS) to match the application of water to the field and crop conditions by regulating individual or zones of sprinklers or the speed of the irrigation system across the field. Varying the application depth to more closely match the soil's infiltration rate can help to minimize some common losses of irrigation water such as runoff and deep percolation.

Sources:

[1] Howell, T.A. and Evett, S.R. 2005. Pathways to effective applications. Proceedings of the 2005 CPIC. Sterling, Colorado, Feb 16-17. [2] Irmak, S., Odhiambo, L.O., Kranz, W.L., and Eisenhauer, D.E. 2011. Irrigation efficiency and uniformity and crop water use efficiency. Publication EC732. University of Nebraska-Lincoln Extension. [3] Yonts, C.D., Kranz, W.L., and Martin, D.L. 2007. Water loss from above-canopy and in-canopy sprinklers. NebGuide G1328. University of Nebraska-Lincoln Extension. [4] Tichota, J. and Petersen, M. 2011. Corn production and strip tillage in the western plains. Monsanto National Research Summary. [5] Yields from a long-term tillage comparison study. CropWatch. University of Nebraska-Lincoln Extension. http://cropwatch.unl.edu/tillage/rmfyields. [6] Schneider, A.D., Howell, T.A., and Evett, S.R. 2001. Comparison of SDI, LEPA, and spray irrigation efficiency. Presented at the 2001 ASABE Annual International Meeting. Paper number 012019. ASABE. 2950 Niles Rd., St. Joseph, MI 49085. [7] Colaizzi, P.D., Schneider, A.D., Evett, S.R., and Howell, T.A. 2004. Comparison of SDI, LEPA, and spray irrigation performance for grain sorghum. Transactions of the ASABE. vol 47(5): 1477-1492. Yonts, C.D. 2008. Surge irrigation management. NebGuide G1868. University of Nebraska-Lincoln Extension. Lamm, F.R., Aguilar, J., Rogers, D.H., and Kisekka, I. 2014. Successful SDI - Addressing the essential issues. Proceedings of the 2014 CPIC. Colby, Kansas, Feb 25-26.

For additional agronomic information, please contact your local seed representative.