Water Application Efficiency

- Irrigation systems should be evaluated in order 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.
- Irrigation systems should be periodically inspected and properly maintained for best performance.
- Management practices such as irrigation scheduling and conservation tillage can help to improve the overall water use efficiency on the farm.

What is Water Application Efficiency?

Water application efficiency is a measurement of how effective the irrigation system is in storing water in the crop root zone. It is expressed as the percentage 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

Irrigation systems should be evaluated in order to limit the following common losses of water from irrigation applications:[1]

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

Water from an irrigation application 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.

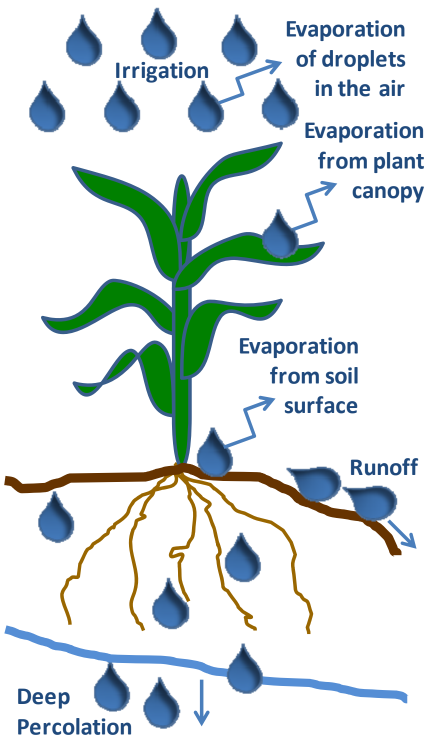

Figure 1. Mechanisms of water losses: evaporation of droplets in the air, evaporation from the plant canopy, evaporation from the soil surface, runoff, and deep percolation.

Considerations for Improving Efficiency

Routine Maintenance: Irrigation systems should be periodically inspected and properly maintained for best performance. The uniformity of water application is also important to check periodically as irregularities in application patterns can lead to yield losses. For example, a detached or malfunctioning sprinkler nozzle could lead to leaching of nutrients from over-irrigation or dry patches in the field.

Irrigation Scheduling: The overall efficiency of water use can be improved when irrigation events are scheduled based on soil moisture estimates or measurements. Soil moisture can be tracked with soil sensors and/or weather-based crop ET estimates to determine when and how much irrigation is needed. This can help to avoid over-watering and crop water stress.

Reduce the Frequency of Irrigations: With certain 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.

Evaporation from crop surfaces is considered the greatest evaporative loss from most sprinkler or spray irrigation systems.[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 1 inch of water in a single application. 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.

Water Measurement: An irrigation flow meter can be used 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.

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 compared to conventional tillage.[4,5]

Furrow Irrigation

Furrow irrigation has one of the lowest application efficiencies among irrigation methods. Water losses include: runoff, evaporation from water in the furrow, evaporation from the soil surface, and percolation below the root zone. Losses due to runoff can be significant if tailwater is not recovered and reused. When furrows are too long, deep percolation can occur at the upstream end of the furrow by the time the downstream end is adequately watered. To avoid percolation losses, it is important to irrigate the entire field as quickly as possible using strategies such as 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.

Sprinkler Irrigation

Common water losses from sprinkler irrigation include: wind drift, evaporation of droplets in the air, evaporation from the crop canopy, and evaporation from the soil surface.[2] The use of lower-pressure sprinkler adaptations that produce larger droplet sizes can reduce water losses due to wind drift and evaporation from the air. Also, consider irrigating when temperatures and wind speeds are low. Moving spray heads closer to the soil surface can result in less wetting of the crop canopy, thereby reducing evaporative losses from plant surfaces.

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.

Microirrigation

Surface and subsurface drip irrigation are low pressure systems with the potential to deliver water at very high efficiencies if designed, maintained, and managed properly. Compared to other types of irrigation, surface and subsurface drip systems tend to have the highest initial investment costs and management requirements, but can also have the highest application efficiencies and crop water productivity, especially under limited water situations.[2,6,7] 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

Variable rate irrigation (VRI) can help to improve water use efficiency on fields where soil type and slope are not uniform. VRI allows the farmer to regulate individual or zones of sprinklers or the speed of the irrigation system across the field in order to match the application of water to the field and crop conditions. 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. Like other precision agriculture technologies, VRI uses Global Positioning Systems (GPS) and Geographic Information Systems (GIS) to determine field characteristics.

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. ASAE. 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.