REDUCING SPRINKLER WATER LOSSES

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The magnitude of sprinkler water losses and the loss components vary primarily with the application device, soil surface and weather conditions. Since there are numerous types of sprinkler application devices, efficiency measurements for each type of sprinkler device are beyond the resources of most manufacturers and agencies. In this paper, we describe the types of water losses and present information about the magnitude of these losses.

TYPES OF WATER LOSSES

Sprinkler irrigation water can be lost to the air, from the wetted plant foliage and from the ground. Figure 1 illustrates these three groups of losses and the individual loss components within each group. Application efficiency, the commonly used index of sprinkler efficiency, is defined as the percent of the sprinkled water stored in the soil for plant growth.

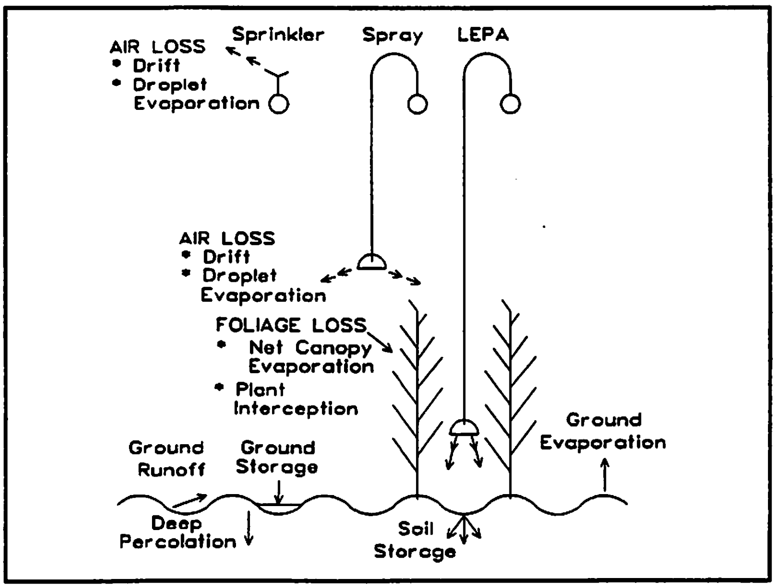

Figure 1. Components of Air, Foliage and Ground Losses During Sprinkler Irrigation.

Air Losses

Sprinkled water can evaporate from the airborne droplets and drift outside the irrigated area. These losses commonly occur with impact sprinklers and to a lesser extent with spray heads. With LEPA, however, air losses are practically eliminated.

Foliage Losses

During sprinkling, water can evaporate from the plant foliage, and it can be stored on the plants after sprinkling ends. In the Great Plains environment, water stored on the plants normally evaporates within two hours after sprinkling ends. Although water evaporating from the plant surfaces reduces transpiration, there is not a one for one trade off, and some evaporation is a net water loss. Foliage losses occur with both impact sprinklers and spray heads, but will usually be less for spray heads because of the reduced wetted area. Foliage losses are minimized with LEPA just as air losses are minimized.

Ground Losses

After sprinkled water lands on the soil surface, it can run off, become surface storage or infiltrate into the soil. The infiltrated water can either be used by the crop or percolate below the root zone. The magnitude of the ground loss components varies with the sprinkler device, soil and topography. With good management deep percolation is negligible regardless of the sprinkler device, however, rainfall may affect percolation losses. Runoff is usually not a problem with impact sprinklers, but it can be a serious problem with spray heads and LEPA because of the higher application rates. Ground storage usually does not occur with impact sprinklers, but with some spray heads and LEPA, surface storage may be used to eliminate runoff and surface redistribution. Soil water evaporation with impact sprinklers and spray heads is often negligible during irrigation even though the entire soil surface is wetted. With alternate furrow LEPA only about a third of the soil surface is wetted, but water ponded in furrow dikes may evaporate for several hours after the irrigation.

SIZE OF WATER LOSSES

Sprinkler water loss components are difficult to measure directly, and the meteorological and plant growth processes are complex and three-dimensional thus making modeling extremely difficult. Studies conducted during the past 50 years, however, provide information for estimating individual losses or groups of losses. Measured application efficiencies have generally been measured in the range of 75 to 90% for impact sprinklers, 80 to 90% for spray heads and 96 to 98% for LEPA.

Comparing application efficiencies of impact sprinklers and spray heads provides information about the difference in air losses for the two devices. Application efficiencies of spray heads are generally about 3 to 5% higher than those for impact sprinklers under the same operating conditions. This is primarily the reduction in air drift and droplet evaporation between the two application devices. The reduced wetted area with spray irrigation also results in less foliage evaporation.

Comparing the application efficiencies of spray heads and LEPA provides information about the size of foliage and ground losses. Application efficiencies for spray heads normally range from 85 to 90%, and 96 to 98% is the usual range for LEPA efficiencies. Thus, the spray head to LEPA efficiency increase is about three times as large as the impact sprinkler to spray head increase.

At the 1991 Central Great Plains Irrigation Workshop Howell et al. (1991) provided a detailed review of sprinkler losses and some application efficiency measurements. Based on their procedures, water losses and application efficiencies for low-angle medium-pressure impact sprinklers, low-pressure spray heads and LEPA are presented in Tables 1 to 3 for 1-in. irrigations. The information is for daytime irrigation of a full canopy corn crop and at wind speeds for which drift losses are small.

For impact sprinklers all potential losses can occur, but runoff and deep percolation are negligible with good management. Air drift and air evaporation will likely be 1 to 3% of the sprinkled water, and we use 3% or 0.03 in. for this water loss. Net canopy evaporation losses can approach 0.02 to 0.04 in./hr, and plant intercepted water can be as much as 0.04 to 0.08 in. For a 2-hr sprinkler application time, we estimate the canopy evaporation as 0.08 in. and the plant intercepted water loss as 0.04 in. The estimated 85% application efficiency is close to the mean of the application efficiencies measured with growing crops in weighing lysimeters (Howell et al., 1991)

Spray irrigation is also subject to all potential losses, but runoff and deep percolation are negligible with good management. Because of the reduced droplet travel distance and time, we estimate the air drift plus air evaporation losses as 0.01 in. With the reduced time of application, we estimate the canopy evaporation loss as 0.04 in./hr for 45 min. or 0.03 in. Plant interception will be essentially the same as for sprinkler irrigation or 0.04 in. The estimated 92% application efficiency is again similar to spray head application efficiency measurements with weighing lysimeters (Howell et al., 1991).

Table 1. Impact sprinkler water loss components and application efficiency for a 1-in. irrigation. Ground evaporation, ground runoff and deep percolation are considered negligible.

Water Loss Component	Method of Calculation	Size of Loss
Air Drift Plus Air Evaporation	3% of 1 in.	0.03 in.
Net Canopy Evaporation	0.04 in./hr for 2 hr	0.08 in.
Plant Interception	0.04 to 0.08 in.	0.04 in.
	Total Loss	0.15 in.
	Application Efficiency	85%

Table 2. Spray head water loss components and application efficiency for a 1-in. irrigation. Ground evaporation, ground runoff and deep percolation are considered negligible.

Water Loss Component	Method of Calculation	Size of Loss
Air Drift Plus Air Evaporation	1% of 1 in.	0.01 in.
Net Canopy Evaporation	0.04 in./hr for 45 min	0.03 in.
Plant Interception	0.04 to 0.08 in.	0.04 in.
	Total Loss	0.08 in.
	Application Efficiency	92%

With LEPA air losses and foliage losses are eliminated leaving only the ground evaporation which should be low because only a third to a half of the surface is wetted. Under a full crop canopy, evaporation from water stored in furrow dikes or pits can be as much as 0.008 to 0.016 in./hr. We estimate the ground evaporation to be 0.01 in./hr for 2 hr for a total water loss of

Table 3. LEPA water loss components and application efficiency for a 1-in. irrigation. Air evaporation, air drift, canopy evaporation, plant interception, ground runoff and deep percolation are considered negligible.

Ground Evaporation	0.01 in./hr for 2 hr	0.02 in.
	Total Loss	0.02 in.
	Application Efficiency	98%

0.02 in. The resulting 98% application efficiency is essentially the same as that reported by LEPA researchers.

DISCUSSION

Keeping the gains to be achieved through improved sprinkler efficiency in proper perspective is important. Consider, for example, a corn crop in the Central or Southern Great Plains requiring 20 in. of irrigation water. Increasing application efficiency 5% by changing from impact sprinklers to above canopy spray heads, would save 1 in. of water. The same gain can be achieved by eliminating just one of twenty 1-in. irrigations through irrigation scheduling or reducing rainfall runoff by 1-in. For the same crop, the 10% gain likely to be achieved by changing from above canopy spray heads to LEPA is equivalent to eliminating two 1-in. irrigations. This is not an argument against increasing sprinkler irrigation efficiency. Instead, this example illustrates that sprinkler hardware, regardless of how sophisticated or expensive, cannot be substituted for good irrigation scheduling and management.

When comparing LEPA application efficiencies with those of impact sprinklers and spray heads, it is important to consider where the water losses occur. Hundreds of tests with catch containers and weighing lysimeters show that the increase in application efficiency by converting from impact sprinklers to spray heads will not likely exceed 5%. On the other hand, converting from spray heads to LEPA may increase application efficiency as much as 10 to 12%. The major gain in application efficiency is made by eliminating foliage evaporation losses rather than air losses. To achieve the efficiency gains, however, requires a complete LEPA system, in which air losses and foliage losses are eliminated, runoff is prevented with enhanced infiltration or surface storage, and soil evaporation is reduced with alternate furrow irrigation.

Spray head placement is not likely to be overly important if the entire crop canopy is wetted. Lowering spray heads from truss rod height to within the canopy is only likely to reduce air evaporation and air drift losses one or two percent. Net foliage losses which are three to four times as large as air losses will be nearly equal regardless of the spray head placement. In-canopy spray and LEPA in the chemigation mode will have essentially the same foliage evaporation losses as above canopy spray so the application efficiency of these methods will be more similar to above canopy spray than to LEPA in the bubble mode. Narrow placement of spray heads is unnecessary as long as the spacing is close enough to provide uniform distribution of the applied water.

REFERENCE

Howell, T.A., A.D. Schneider and J.A. Tolk. 1991. Sprinkler evaporation losses and efficiency. Proc. Central Great Plains Irrigation Short Course. North Platte, NB. Feb. 5-6, 1991. p. 69-89.