NebGuide

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Water Loss from Above-Canopy and In-Canopy Sprinklers

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This NebGuide compares the water that is lost from center pivot sprinkler devices when operated at different heights in relation to the crop canopy.

Center pivot systems are currently being designed for lower operating pressures as one way to reduce pumping costs. Many of the low-pressure sprinkler devices have been designed to operate on drop tubes below the center pivot pipeline. Operating low-pressure sprinkler devices closer to the crop canopy is considered more efficient than high pressure systems. The efficiency improvement is thought to result from reducing the amount of water lost through evaporation and wind drift. Because wind speeds are reduced at locations nearer to the soil surface or crop canopy, placing a sprinkler device just above the canopy reduces the amount of distortion in the sprinkler pattern and drift due to wind.

As low-pressure sprinkler devices became more common, producers began moving the devices from above the canopy to within the canopy in hopes of reducing water loss even more. In Nebraska, in-canopy operation occurs mainly in corn production. Before adopting in-canopy operation, however, a better understanding of how much water can be saved when converting from above-canopy to in-canopy operation is needed. More importantly, changes in water application that occur with in-canopy operation must be understood. This NebGuide discusses the water-saving and runoff potential of sprinkler devices used within the crop canopy.

Where Water Loss Occurs

Water loss from sprinkler devices occurs in three main areas — through the air, from the canopy and from the ground. Water loss in the air can occur both as evaporation before water reaches the plant or as drift away from the application site. Once on the canopy, water loss occurs primarily through evaporation from plant leaves. When water reaches the soil surface, losses can occur from either runoff or evaporation. Water is considered to be runoff if it moves over the soil surface and off of the field or moves within the field into lowlands resulting in deep percolation. Water stored on the soil surface is not considered lost if it remains near the point of application and infiltrates into the soil over time.

Water Loss Measurements

To determine how much water loss occurs in the air above the canopy, within the plant canopy and from the soil surface, researchers in Texas (Schneider and Howell, 1995) compared different sprinkler devices and heights of sprinkler devices with respect to the crop canopy. *Table I* gives the water loss during irrigation and the application efficiency for 1) six-degree low-angle impact sprinklers located on the sprinkler pipe, 2) spray heads located 5 feet above the ground and 3) Low Energy Precision Application (LEPA) system using bubblers located 1 foot above the ground. Both the water loss and application efficiencies given are based on a daytime irrigation of 1 inch applied to mature corn under no wind conditions. Evaporation from the soil during irrigation is assumed to be negligible for the low angle impact sprinkler and spray head, a result of evaporation demands being met by the water evaporating from plant leaves.

Table I. Sprinkler water losses and application efficiency for 1-inch water application.

Water Loss Component	*Low-Angle Impact Sprinkler Water loss*	*Spray Head Water Loss*	*LEPA Water Loss*
Air Evaporation and Drift	0.03 in.	0.01 in.	0.00 in.
Net Canopy Evaporation	0.08 in.	0.03 in.	0.00 in.
Plant Interception	0.04 in.	0.04 in.	0.00 in.
Evaporation From Soil	Negligible	Negligible	0.02 in.
Total Water Loss	0.15 in.	0.08 in.	0.02 in.
Application Efficiency	85%	92%	98%

The amount of water lost between the sprinkler nozzle and the top of the crop canopy, air evaporation and drift, is 3 percent for low-angle impact sprinklers and 1 percent for spray heads. Low-angle impact sprinklers lost 8 percent from the canopy, while spray heads lost 3 percent. These differences primarily can be attributed to the length of application time. Low-angle impact sprinklers keep the plant canopy wet longer than spray heads, allowing more opportunity for evaporation. Application efficiency is improved by reducing the amount of evaporation from the crop canopy. Reducing water losses in the air results in less improvement in application efficiency.

Based on Schneider and Howell's results, and a review of other studies, converting from low-angle impact sprinklers to spray heads can improve application efficiency by up to 5 percent. Converting from low-angle impact sprinklers to a LEPA system can increase efficiency by 10 to 12 percent.

LEPA System

The LEPA system, with a 98 percent application efficiency, has no air or canopy water loss since water is applied near the ground, below the canopy. However, to realize the potential improvements in application efficiency using LEPA, a complete LEPA system, including the following, must be adopted:

1. The crop must be planted in a circular pattern on center pivots;
2. Drop tubes must be placed at a height of 12 to 18 inches between every other crop row;
3. Water must be discharged in the bubble mode or through socks to avoid wetting plant leaves;
4. Surface storage must be created to prevent any runoff and maintain infiltration uniformity.

LEPA systems apply water to the soil more rapidly than can be immediately infiltrated. Surface storage allows the water to pond temporarily until infiltration is complete. Evaporation from the soil is kept low by having drop tubes between every other crop row.

In the Texas study, the spray heads were operated at a constant height of 5 feet. Maintaining a constant height is more likely if drops are located between corn rows planted in a circle. Under pivots planted to straight rows, keeping the sprinkler device at a constant height within the canopy is difficult, especially at heights of 2 to 3 feet. As a pivot moves, drops catch on the corn plants. Sprinkler devices, rather than being held horizontally at the desired height, are held at an angle at a much greater height for a majority of the time. As a result, straight-row in-canopy operation applies water to a high percentage of the crop canopy, just as if the spray head were located above the canopy. In most cases the water savings by moving sprinkler devices from above-canopy to in-canopy is on the order of 1 to 2 percent. Even during days when wind drift is introduced, water savings is likely to be less than 5 percent.

Runoff Measurements

In a separate study, Schneider and Howell (1997) measured corn yield under both full and deficit irrigation, with no runoff, for LEPA, above-canopy and in-canopy irrigation systems. Within an irrigation level, they found no significant difference in yield between the irrigation methods tested. In other words, the small improvement in irrigation efficiency using the different systems was not enough to measure a difference in crop yield even under limited irrigation conditions.

On the other hand, in Texas' 1995 work, runoff was assumed to be negligible. This is correct as long as infiltration is increased to meet the increased application rate or tillage is used to provide surface storage. More recent research out of Texas (Schneider, 2000) has shown that runoff can be as high as 52 percent. This level of runoff occurred over a two-year period for a LEPA system operating in the bubble mode on a clay loam soil. Because the soils intake rate was less than the sprinkler application rate, runoff occurred. The loss of over half of the applied water through runoff, resulted in a 25 percent yield reduction in corn. From this information, it is clear that runoff reduces the water application efficiency. Examples and methods of how soil type, field slope, system capacity, application depth and wetted diameter can influence runoff are given in: *Water Runoff from Sprinkler Irrigation - A Case Study,* NebGuide G96-1305.

Summary

The amount of water lost through evaporation and wind drift has been estimated and assumed for many years. The work described here is some of the first to separate and measure the different water loss components and determine the effect of these variables separately on yield. Converting from a high-pressure to a low-pressure sprinkler system is a method to reduce energy costs. Once the operating pressure is reduced, simply moving low-pressure sprinkler devices into the crop canopy does not save additional energy.

When compared to devices placed just above the mature crop canopy height, moving low-pressure sprinkler devices from above to within the crop canopy provides little savings in water and has no impact on yield if runoff in the field is controlled. Left uncontrolled, low-pressure sprinkler devices operating in the crop canopy can result in significant runoff and subsequent yield loss. When sprinkler devices are operated within the crop canopy, changes occur with respect to the application pattern of water on the soil surface. To learn about the impact of in-canopy operation on sprinkler uniformity, see *Application Uniformity of In-canopy Sprinklers,* NebGuide G97-1337.

The University of Nebraska recommends locating sprinkler devices above the mature crop canopy. This location allows the operator to take advantage of low-pressure operation yet allows the sprinkler device to distribute water uniformly without interference from the crop canopy. This results in minimizing water loss, reducing runoff potential, and reducing installation and operation costs.

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