Water Runoff from Sprinkler Irrigation --- A Case Study

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When water is applied through a sprinkler irrigation system, it should soak into the soil where it lands rather than flow to a low spot in the field or runoff the field. Runoff causes nonuniform water application, poor irrigation efficiency, and possible leaching of chemicals to the groundwater. Some systems like LEPA (low energy precision application) are designed so that water does not immediately soak into the soil. However, proper LEPA designs also call for tillage practices that hold the water on the soil surface where it lands until it has time to infiltrate into the soil. All sprinkler systems should be designed for no water leaving the point of application or zero runoff.

This NebGuide will illustrate, through an example center pivot, the influence of soil texture, topography, and irrigation system characteristics on potential runoff. The example covers conventional tillage with no allowance for surface storage of water due to tillage. Additional background information for this case study can be found in: *Water Runoff Control Practices for Sprinkler Irrigation Systems, NebGuide G91-1043; and Selecting Sprinkler Packages for Center Pivots, NebGuide G88-870.*

Case Study

The base system characteristics of this example center pivot are given in Table 1a. Each characteristic in the table can influence the potential for runoff. Soil texture and intake family, defined by the Natural Resource Conservation Service (NRCS), determine how fast water will infiltrate into the soil. In this example we are dealing with a silt loam soil that has an intake family of 0.3. Field slope influences how much water might naturally puddle or infiltrate later, and how easily the water might flow to a lower part of the field. In this example we have a moderate slope of 3-5%.

The characteristics of the center pivot system influence how intensely water is applied to the soil. In this example, system capacity is 800 gallons per minute, system length is 1340 feet, application depth is 1 inch of water per revolution, and wetted diameter of the sprinkler heads is 40 feet. The overall runoff resulting from this field system is 26%, which means that 26% of the water pumped through the system did not infiltrate where it landed. The runoff moved to a lower part of the field or it left the field reducing the water application efficiency by 26%.

Each of the land surface factors and center pivot characteristics are varied individually in Table 1b – 1g. These examples show how each factor influences the overall runoff from the field.

Soil texture cannot be changed in a given field; it has a tremendous impact on runoff as shown in Table 1b. A soil in intake family 0.1 (clay, silty clay, or silty clay loam) has very slow infiltration and produces 44% runoff from our base system. However, silt loam, very fine sandy loam, fine sandy loam, or loamy fine sands in the 1.0 intake family can infiltrate all of the applied water with zero runoff.

Slope (or changes in field elevation) is another factor that cannot be changed. Table 1c shows a field with a slope of 1-3% has limited runoff to 8%, while a slope greater than 5% can produce runoff equal to 35% of the water applied. The influence of land surface factors on runoff shows that sprinkler packages must be designed for each field. As soils and slopes vary from field to field, sprinkler packages must be closely matched to the conditions of that field.

Irrigation system capacity influences the application rate or intensity if other system characteristics are the same. Table 1d gives the influence of changing system capacity on runoff. When system capacity drops to 700 gallons per minute, runoff is 22%. When system capacity increases to 900 gpm, runoff is 29%. Although not given in Table 1, runoff is greater near the outer end of the system than near the center. Outer spans have more area to water in the same amount of time which gives less time for the water to infiltrate into the soil. Thus, the greatest potential for runoff exists at the outer spans of the system.

Application depth of each irrigation event also influences runoff. Table 1e shows that if the operator speeds up the pivot and puts on 0.75 inch instead of 1.0 inch, runoff is reduced to 16%. If the pivot is slowed to put on 1.25 inches, runoff increases to 33%. The practical limits for irrigation applications are normally 0.75-1.25 inches. Smaller applications are less efficient in delivering water to the crop. Larger applications have the potential for more runoff.

Wetted diameter of the sprinkler pattern has a large influence on runoff, as presented in Table 1f. The wetted diameter is determined by the type of sprinkler device and operating pressure of the irrigation system. A minimum wetted diameter should be selected to produce little or no runoff. Eliminating runoff through sprinkler selection is more important than moving the sprinkler heads nearer or into the canopy to reduce water loss. As shown in Table 1g, more than one system characteristic may need to be changed to reduce runoff to acceptable levels. Here the application depth was reduced to 0.75 inch and the wetted diameter was increased to 60 feet for an overall runoff of 7%. A further increase in wetted diameter to 80% reduced overall runoff to 2% of the applied water.

A computerized program, *Estimating Potential Runoff and Energy Savings from Sprinkler Package Conversions,* is available from Nebraska Cooperative Extension. It calculates potential runoff from all combinations of soil types, field slope, system capacity, system length, application depth, and wetted diameter. Choosing the right sprinkler package is important for least cost irrigation of a particular field. The best sprinkler device may or may not operate at the lowest pressure. The system selected needs to eliminate or minimize runoff to deliver water efficiently and uniformly to the field.

Table 1. Example of runoff potential from a center pivot irrigation system.

Soil Intake Family	Slope (%)	System Capacity (gpm)	System Length (ft)	App. Depth (inches)	Wetted Diameter (feet)	Potential Runoff (%)
Table 1a. Base system characteristics.						
0.3	3-5	800	1340	1.0	40	26
Table 1b. Influence of soil intake family (soil texture) on runoff.						
0.1	3-5	800	1340	1.0	40	**44**
0.5	3-5	800	1340	1.0	40	**11**
1.0	3-5	800	1340	1.0	40	**0**
Table 1c. Influence of slope on runoff.						
0.3	**0-1**	800	1340	1.0	40	**0**
0.3	**1-3**	800	1340	1.0	40	**8**
0.3	**>5**	800	1340	1.0	40	**35**
Table 1d. Influence of system capacity on runoff.						
0.3	3-5	**500**	1340	1.0	40	**14**
0.3	3-5	**700**	1340	1.0	40	**22**
0.3	3-5	**900**	1340	1.0	40	**29**
Table 1e. Influence of application depth on runoff.						
0.3	3-5	800	1340	**0.50**	40	**3**
0.3	3-5	800	1340	**0.75**	40	**16**
0.3	3-5	800	1340	**1.25**	40	**33**
Table 1f. Influence of wetted diameter on runoff.						
0.3	3-5	800	1340	1.0	**30**	**48**
0.3	3-5	800	1340	1.0	**60**	**15**
0.3	3-5	800	1340	1.0	**80**	**8**
Table 1g. Influence of application depth and wetted diameter on runoff.						
0.3	3-5	800	1340	**0.75**	**60**	**7**
0.3	3-5	800	1340	**0.75**	**80**	**2**