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G91-1043 Water Runoff Control Practices for Sprinkler Irrigation Systems

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Water Runoff Control Practices for Sprinkler Irrigation Systems

This NebGuide describes techniques to help reduce water runoff from fields irrigationd with sprinkler irrigation systems.

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Water runoff is often a problem associated with sprinkler irrigation systems operated on sloping terrain. Soil particles, fertilizers and pesticides can become part of runoff waters and can be moved from their target locations, causing degradation of surface water quality.

Other potential problems associated with runoff include a lack of soil moisture in localized areas of the field, crop nutrient deficiencies, washed-out seeds or plants, and increased irrigation water pumping costs.

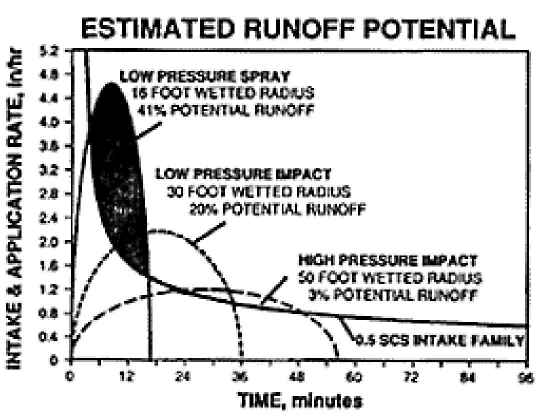

Figure 1. Estimated runoff potential for low pressure spray, low pressure impact, and high pressure impact sprinkler packages installed on a 1,320 foot center pivot with a system capacity of 800 gpm, applying 1.0 inch of water to a silt loam soil with a field slope of 3 to 5 percent.

Runoff can occur when the rate of rainfall or irrigation water application exceeds the infiltration rate of the soil, or the rate at which the soil can absorb water. The amount of runoff depends primarily on the amount and rate of water application, soil infiltration rate, field slope, and conditions present at the soil surface such as crop canopy or residue cover. To varying degrees all of these factors can be changed, reducing the potential for runoff.

Figure 1 illustrates the percentage of water applied by low pressure spray, low pressure impact, and high pressure impact sprinkler packages that is in excess of the soil infiltration rate for a silt loam soil. The figure shows that reducing application time, thus increasing the water application rate, increases the potential for runoff.

Problem Identification

The runoff potential for each field must be evaluated before selecting the most appropriate control practice or combination of practices. The best way to do this is to observe the operation of the sprinkler system. Since the potential for runoff typically increases as the season progresses, conditions also should be observed at multiple times throughout the growing season.

Primary areas to check include the more steeply sloping areas of the field and the outer two or three towers of a center pivot system. These are generally the areas where runoff is most likely to start, and where it will be the most severe.

It is important to recognize the magnitude of the actual or anticipated runoff problem. Runoff problems can be placed into three categories:

- *Minor runoff problems* are those where small channels of water move visibly downslope, but the channels extend only for a short distance.
- *A moderate problem* is when more extensive rills or channel systems develop and extend downslope over greater distances, but normally don't go beyond the field boundaries.
- *A severe runoff problem* exists when gullies form in certain areas, or when concentrated water flows leave the field boundary.

The severity of the runoff problem determines what control approach should be taken. Other factors that enter into this decision may include crop water needs, field slope, soil characteristics, regional climatic variations, and equipment availability.

Runoff Control Options

Minor runoff problems that occur or are anticipated often will be corrected by simple changes in cultural practices or irrigation system management. These changes may include the type and number of tillage operations, or reducing the amount of water applied per irrigation event.

Moderate runoff problems may require alterations to the irrigation system design in conjunction with changes in cultural and management practices. For example, reducing the peak water application rate or increasing the sprinkler wetted radius and reducing tillage operations may control a moderate runoff problem.

In severe runoff situations, specialized tillage practices, used in conjunction with other changes, may be necessary.

Cultural Practice Changes

Leaving crop residue on the soil surface generally reduces the amount of water runoff, particularly for water applications of one inch or less. Crop residue works in a number of different ways to reduce runoff and erosion.

When water droplets strike a bare soil surface, energy contained in the droplets is transferred to the soil, often forming a crust. Although this crust is normally less than 0.1 inches thick, it can reduce the infiltration rate by more than 50 percent. Residue effectively absorbs much of this impact energy, reducing crust formation.

Residue increases the soil surface roughness, which helps dissipate the energy from flowing water. This, in turn, reduces the amount of erosion that occurs.

The intricate series of small dams created by the residue increases both the amount of water stored on the soil surface and the time available for water to infiltrate into the soil. Finally, residue reduces soil moisture evaporation, thus potentially reducing the number of irrigation events.

The type of crop residue is not critical. The key is to leave an adequate amount of well-distributed residue on the soil surface. Refer to NebGuides *G81-544, Residue Management for Soil Erosion Control,* and *G91-1046, Conservation Tillage and Planting Systems*, for additional information.

Another cost-effective approach to runoff control is contour farming, which can reduce runoff by up to 50 percent compared to farming up-and-down hill. Contouring reduces the slope length in the downstream direction, decreasing runoff potential and increasing the time water can infiltrate into the soil. No-till planting on the contour is especially effective in reducing both soil erosion and water runoff.

Irrigation System Design and Management

There are at least five items related to irrigation system design and/or management that can substantially reduce or eliminate the amount of runoff. These involve matching irrigation system water application characteristics to soil conditions by:

- selecting a sprinkler package that matches field conditions;
- increasing the wetted radius of the individual sprinkler heads;
- reducing the system capacity or water flow rate;
- reducing the water application volume or depth for each irrigation event; and
- limiting the amount of water applied to soils without a crop canopy or residue cover.

If a new sprinkler system or extensive changes to an existing system are planned, the water application characteristics of the proposed sprinkler package should be matched to the infiltration characteristics of the soil. Extension irrigation specialists can provide information such as that shown in *Figure 1*. A sprinkler package option should not be considered if excessive runoff is likely. For further information, refer to NebGuide *G88-870, Selecting Sprinkler Packages for Center Pivots* .

The wetted radius of an individual sprinkler head partially controls the length of time water is applied to a given area of the soil surface, and the sprinkler peak water application rate. In general, the larger the wetted radius, the smaller the potential for runoff. Potential runoff estimates obtained from computer simulations for wetted radii of 16, 30 and 50 feet were 41 percent, 20 percent and 3 percent, respectively (*Figure 1*).

Reducing the flow rate of water into the sprinkler system decreases the peak rate at which water is applied to the soil. Decreasing the peak application rate reduces the amount of runoff, since the water application rate is more closely matched to the infiltration rate of the soil. Reducing the system flow rate also reduces the amount of water that can be applied per day. Remember that the system flow rate must be capable of meeting crop water needs. To determine the minimum system design capacity needed refer to NebGuide *G89-932, Minimum Center Pivot Design Capacities in Nebraska*.

Runoff potential decreases as the amount of water applied during each irrigation event decreases. However, a greater number of irrigations may be required to compensate for the reduced application amount. More irrigation events could reduce the life of the center pivot.

A goal of sprinkler system management should be to apply as much water as possible during each irrigation event, but only up to the amount where runoff just begins to occur. The timing and number of irrigations should be determined through proper irrigation scheduling. Refer to NebGuide *G85-753, Irrigation*

Scheduling Using Crop Water Use Data, for further information.

Soil crust formation will be much more rapid when irrigation water is applied to a bare soil surface. If possible, irrigation should be delayed until a crop canopy has developed, particularly when little or no residue has been left on the soil surface.

Specialized Tillage Practices

If water runoff and soil erosion problems persist despite cultural and management practice changes, certain specialized tillage practices can be considered. These practices either alter the soil surface to provide additional water storage, modify the soil structure to increase water infiltration, or combine the two.

Specialized tillage practices can be quite energy intensive, so a severe runoff problem is necessary to justify their use as water conservation measures. These practices should be limited to sprinkler-irrigationd fields due to the possibility of severe crop stress immediately following tillage. Under dryland conditions, plant stress could result in substantial yield reductions.

Water infiltration can be increased by eliminating a compacted soil layer or by increasing the amount of air spaces contained in the soil. Eliminating a compaction layer is costly; it requires specialized equipment and proper soil moisture conditions. Compaction should be well documented before special tillage is used to eliminate the problem.

Temporary surface storage increases the time available for water to infiltrate. Rough soil surfaces can retain a considerable amount of water.

Soil surface storage can be increased by creating small basins or reservoirs at the soil surface. This is done by mounding loose soil on the surface to create small dams between the rows, or by creating small depressions below the soil surface.

Three specialized tillage practices have been evaluated at three Nebraska locations under three field slope conditions. The tillage could be conducted early in the season or as a last pass prior to harvest. Success often depends on soil moisture content at the time the tillage is performed.

Subsoiling uses a chisel shank operated at a depth of 10 to 12 inches (*Figure 2*). The shank is positioned midway between the crop rows to uplift and partially shatter the soil profile, increasing the infiltration rate and creating a rough soil surface. This practice is most effective when the soil is relatively dry. If the tillage is done on wet soil, much less soil shattering occurs.

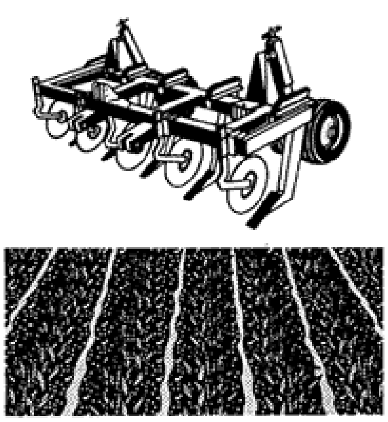

Figure 2. Subsoil tillage implement and soil surface conditions.

Research in other states indicates runoff can be reduced and, in some cases, a yield increase can result when subsoiling is used on fields with slopes less than 5 percent. Research conducted at Concord, Clay Center and Kearney, Nebraska has failed to show a yield increase.

When subsoiling was used up and down hill with field slopes of 5 percent or greater, the shank opening provided a downhill channel for water flow. Water remained on the surface but was concentrated in the shank opening, resulting in more runoff than from conventional tillage practices (*Table I*). For these reasons, subsoiling is not recommended on field slopes greater than 5 percent, unless the field is farmed nearly on the contour.

The potential for temporary moisture stress of the crop is an additional concern. The shattering effect of subsoiling detaches some roots from the soil and prunes others. If a prolonged hot, dry period follows the tillage operation, substantial yield reductions may result. Thus, 0.5 to 0.75 inches of water should be applied as soon as possible after tillage. The water application slightly seals the soil surface, reducing evaporation and aiding in the regrowth of pruned roots.

Basin Tillage implements consist of small paddles or a set of disk blades installed behind a cultivator shank (*Figure 3*). The implement drags loose soil from between the crop rows for a preset distance, often 3 to 8 feet, and deposits it across the row middle, creating a small dam. The area upslope from the dam becomes a small water storage basin. This practice has been used successfully for runoff control on field slopes of less than 5 percent in other states.

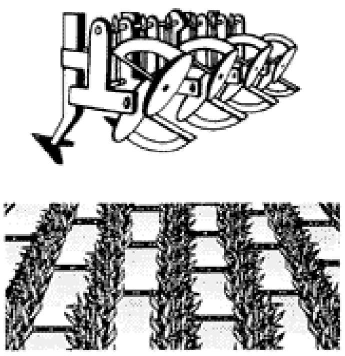

Figure 3. Basin tillage implement mounted on a cultivator and soil surface ponding conditions.

As field slope increases, the failure potential of individual dams increases. When a dam fails, water stored in the basin enters the basin immediately downslope, increasing the volume of water in storage. The worst-case scenario, failure of all basins, could produce more runoff than from conventional tillage systems.

Basin tillage equipment requires an adequate supply of loose soil. Minimal loose soil on the surface results in shallow dams, less storage capacity, and a greater potential for individual dam failure. The field should be cultivated at least once prior to using this implement.

Implanted Reservoir implements combine the concepts of a subsoiler and basin tiller to create small depressions below the soil surface. Like the subsoiler, the implanted reservoir implement uses a chisel shank operated to a depth of 10 to 12 inches. Large paddle wheels are installed behind each shank (*Figure 4*). The paddles create depressions approximately 10 inches in diameter and 8 to 10 inches deep at intervals of approximately 2 feet.

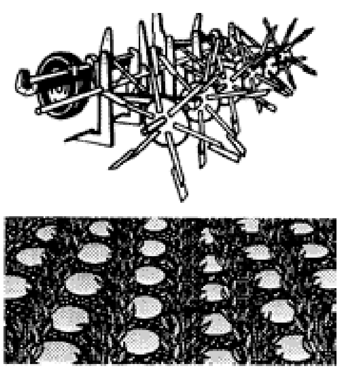

Figure 4. Implanted reservoir tillage implement and soil surface ponding.

The chisel shank shatters and uplifts the soil profile to increase the soil infiltration rate, and the paddle wheels create small depressions to retain water. The main difference between the basins created by the basin tiller and the implanted reservoirs is that the reservoirs are below the normal soil surface. This factor aids in reducing the potential for storage area wash-out.

Implanted reservoirs provided the greatest runoff control of the three specialized practices on a 10 percent slope (*Table I*). Similar to the subsoiler, a 0.5 to 0.75 inch water application should follow the tillage operation to reduce water stress due to root pruning.

Under Nebraska conditions, the depressions often remain intact throughout the season. This poses a problem during harvest. The wheels on some combines, tractors and grain wagons drop into the depressions, causing a rough ride and extra stress on equipment axles.

One alternative is to adjust wheel spacings to run over the row rather than between the row. Another alternative is to not use the paddle wheels in normal wheel track areas and to concentrate driving in the untreated areas. However, this reduces the overall effectiveness of runoff control.

Summary

Cultural practice changes are usually the most cost-effective means of reducing water runoff from sprinkler irrigation systems. For example, no-till planting in conjunction with contour farming usually provides an effective means of controlling minor runoff problems, and greatly reduces moderate or even severe runoff problems.

When cultural practice changes are combined with irrigation system management and/or design changes, the vast majority of runoff problems can be eliminated.

Specialized tillage practices to correct runoff problems should be considered only as last resort measures, after all other options have been exhausted. The temporary nature of these practices, high horsepower requirements, potential harvesting problems, root pruning and other limitations can have a significant impact on the economics of these techniques.

Table I. Percent runoff resulting from two inches of simulated rainfall studies conducted at Clay Center, Lincoln and Concord, Nebraska.*

Tillage	**Percent Slope and Location**		
	Clay Center 1%	**Lincoln 5%**	**Concord 10%**
Conventional Tillage[1]	5	8	25
Subsoil	6	2	41
Basin Tillage	**	***	12
Implanted Reservoir	5	***	8

* All runoff was determined following 2 inches of water application.
** Soil conditions were unsuitable for creating basins with the equipment used.
*** Tillage treatment not evaluated
[1]Conventional Tillage:
CLAY CENTER - Fall Disk, Spring Harrow, Plant, Cultivate
LINCOLN - Moldboard Plow, 2 Diskings, Plant
CONCORD - Shred stalks, Disk, Plant

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