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Crop Residue and Irrigation Water Management

Crop residue cover and tillage practices play important roles in the way that crops use water, and also affect the ability of irrigation systems to replace that water. The effects of these practices and other influencing factors are discussed in this NebGuide.

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Tillage practices and crop residue management play an important role in the way that irrigation systems perform and are managed. Tillage practices affect the way that water moves into and off of the soil (infiltration and runoff). Tillage practices also affect the way that water moves from the soil into the atmosphere (evapotranspiration).

Effect of Tillage on Furrow Irrigation Management

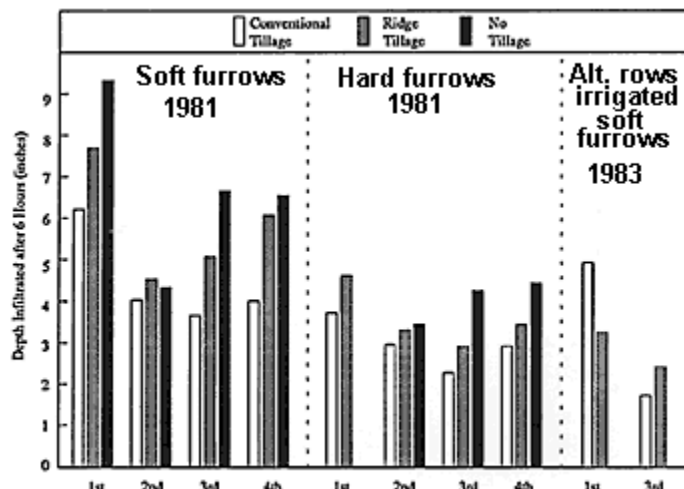


Figure 1. Example of the effect of tillage practices on infiltration characteristics.

Many factors affect the performance of furrow irrigation systems. Physical conditions such as soil texture, soil structure, field slope, field length, furrow shape, and the amount of crop residue cover, all have some impact on the performance of the irrigation system. The way the system is managed, including the furrow flow rate, length of application time and irrigation frequency, also affects system performance. Irrigation system performance is

often measured in terms of the percentage of the water applied that remains in the active root zone after the irrigation event (application efficiency). Thus, deep percolation (water passing through the root zone) and runoff (tail water) should be held to a minimum while supplying adequate water to the crop along the length of the furrow. Systems having runoff return facilities are exceptions, since runoff is only counted as a loss to the extent that the return system leaks.

Tillage practices affect furrow irrigation systems by altering the infiltration characteristics of the soil and by altering crop residue in the furrow. Both of these factors affect the ability of the furrow to convey water down the field. As tillage practices become less intensive, infiltration rates often increase. An example of this is shown in *Figure 1* (Eisenhauer et al., 1984). Studies on a Hastings silt loam soil under different tillage practices showed that as tillage practices become less intense (conventional tillage --> ridge tillage --> no tillage), infiltration rates increased in 8 of 10 cases.

An example case from *Figure 1* can be used to illustrate how changes in infiltration rate affect the overall performance of the irrigation system. If the infiltration characteristics of a soil at the time of irrigation are known, the performance of the irrigation system may be estimated using a computer model. These models predict the results of a furrow irrigation event given the physical and management factors used. An example using the measured infiltration parameters from *Figure 1* (1981, 4th irrigation, soft furrows) is:

1320 foot furrow length	25 gpm furrow flow rate
0.15% furrow slope	12 hour set time
3 inch soil moisture deficit	runoff return system

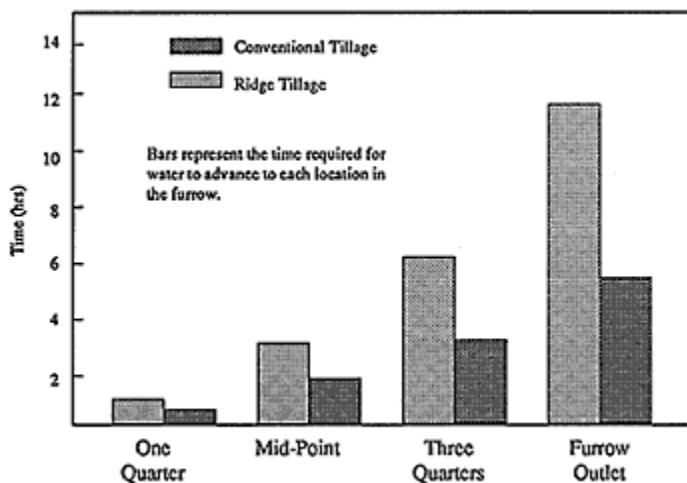


Figure 2. Example of the effect of infiltration rate on the rate of advance of water down the furrow.

For this example, all parameters are held constant except for infiltration rates which are changed to reflect conventional tillage or ridge tillage systems. *Figure 2* shows the rate that water advances down the furrow for both tillage system examples. The ridge tillage system had higher infiltration rates, resulting in slower advance. This causes less runoff time, less runoff volume and more deep percolation. The total application amount is

the same in either case because the furrow flowrate and application time are the same. In this example, water advanced to the end of the furrow in approximately 5 hours under conventional tillage and in almost 12 hours under ridge tillage.

Figure 3 shows that changes in the advance rates create changes in the amount of water infiltrated at any point down the furrow length. The ridge tillage system caused more infiltration and was less uniform (much more infiltration at the furrow inlet than at the outlet). In the conventional tillage example, 23 percent of the applied water left the field as runoff, and was returned and used elsewhere in the field.

This results in an application efficiency of up to 53 percent. The ridge tillage example had only 1 percent runoff and an application efficiency of 41 percent.

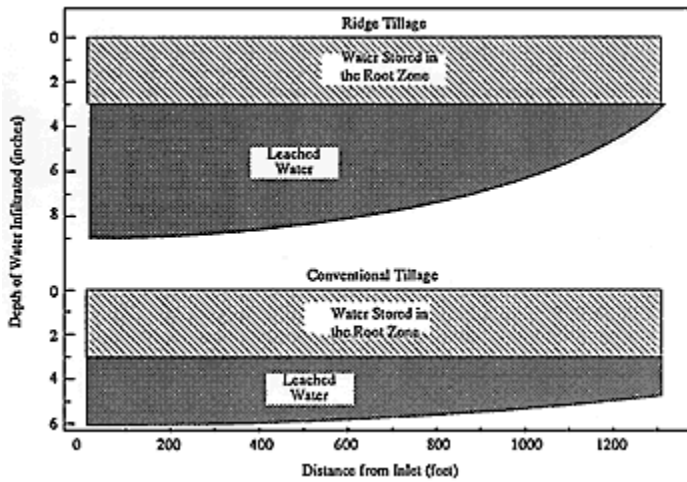


Figure 3. Example of the effect of advance rates and infiltration characteristics on infiltration profiles.

This example shows the effect of an increase in infiltration rates with **no changes in management**. Both example cases could be more efficient if a shorter set time and higher flow rate were used. In fact set time and flow rate combinations exist that would make **both cases equally efficient**. This illustrates the need to match management factors with the physical conditions present at the time of irrigation. In some cases, a change in tillage

practice may cause changes in infiltration rates that are too severe to overcome with management factors alone. In these cases physical changes to the system may be necessary. The field slope or length of run may need to be changed, or furrow packing or surged flow may be used to help overcome problems associated with extreme changes in infiltration characteristics.

Effect of Tillage and Crop Residue on Center Pivot Irrigation

Crop residues serve a largely positive role in center pivot irrigation management. Selecting a tillage system that is best suited for a particular field situation can be a very important decision. Disregard for the importance of this decision could directly affect the effectiveness of the water application system, as well as other crop production practices.

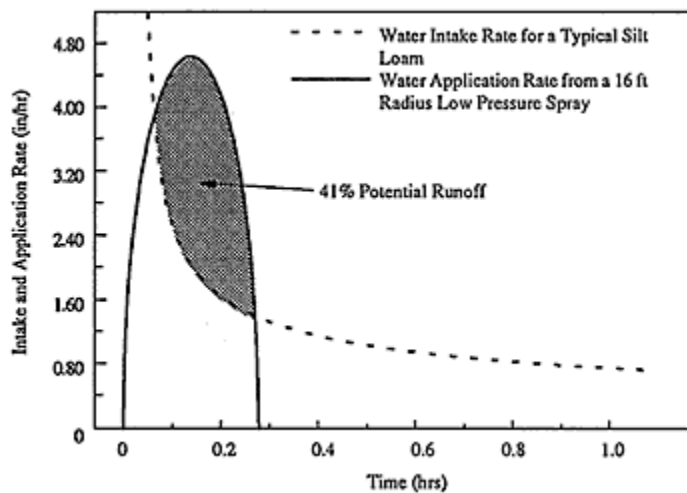


Figure 4. Potential runoff calculated for a low pressure spray nozzle irrigating a field with silt loam soil.

In general, concerns associated with tillage practice selection and center pivot operation are related to the potential for runoff and erosion. The potential for runoff exists whenever the water application rate of the irrigation system exceeds the infiltration rate of the soil. This is shown in *Figure 4*. The shaded area represents the amount of water applied in excess of the average soil infiltration rate.

To lower pumping costs, some irrigators retrofit their machines with low to medium pressure sprinkler packages. On occasion, sprinkler packages may be improperly matched with the soil infiltration rate. Irrigation system management and tillage practices may be used to control runoff if changes in the irrigation system itself are desirable.

One option is to reduce the application depth per irrigation. In doing so, the operator reduces the

potential for runoff but increases the opportunity for soil evaporation over the course of the growing season. While crop residues can help reduce the magnitude of soil evaporation losses, repeated wetting of the soil surface will limit the water savings attributed to crop residues.

Runoff may also be generated if the soil infiltration rate is reduced over a period of time. A number of factors such as soil texture and structure, surface tillage, or water application can cause a reduction in infiltration. For example, as the size and number of water droplets increases, fine soil particles are consolidated on the surface to form a thin crust. As the soil crust develops, the water infiltration rate tends to decrease. Soil surface crusts can result in infiltration rate reductions of up to 75 percent. One way to combat the negative effect of water droplets is to be sure that crop residues are distributed evenly over the soil surface. Crop residues spread in this manner protect the soil by absorbing energy carried by falling water droplets. This limits soil crust development, resulting in a more consistent infiltration rate throughout the growing season.

Once the previous year's crop has been distributed over the soil surface, selection of a tillage practice, whether used as a single operation or in conjunction with other operations, directly impacts the amount of soil surface covered with residue. This is particularly true of soybean residues which are produced in less quantity and are considerably more fragile than small grain or corn residues. Thus, if needed, tillage practices that result in minimal soil disturbance should be used when topography is rolling or the previous crop was soybeans. If the previous crop was corn or small grains, more soil disturbance is tolerable although its potentially negative effect on soil infiltration should be considered. On highly erodible land (HEL), it is important to check for compliance with conservation plans in making these decisions.

Crop residues also act like small dams for temporary soil surface storage of excess water. Water applied in excess of the soil infiltration rate will be blocked from running off the field long enough for infiltration to occur. This results in more uniform water application. In the process, soils that would have been transported with the runoff water remain near their point of origin.

Another option is to alter the operating characteristics of the irrigation system. For example, by selecting a sprinkler package based on soil type and field topography, the water application rate of the center pivot can be more closely matched with the soil infiltration rate. By considering the interaction between the sprinkler package and soil, selection of an unsuitable sprinkler package can be avoided.

The combination of improved water application uniformity resulting from more consistent infiltration rates, less runoff and reduced soil evaporation losses make crop residues a major factor in the water conservation effort. Residue management also can be a crucial component to minimizing the effect of irrigation on surface water quality.

Crop Residue Management and Evaporation from Soils

Crop residue on the soil surface reduces evaporation. Most of the evaporation occurs when the soil is wet, within a few days after rain or irrigation. The residue insulates the wet soil from solar energy and reduces evaporation. When soil is wet more often, as in the case of sprinkler irrigation, evaporation increases and crop residue contributes even more to evaporation reduction. Crop canopies also play a role in reducing evaporation by shading the soil surface.

Crop residues are often left on the surface in dryland crop rotations. Weed-free wheat stubble in west central Nebraska can reduce evaporation by 2 inches compared to bare soil, from wheat harvest in July until row crop planting the following May. This water savings can contribute to yield increases of up to

10 bushels of corn per acre.

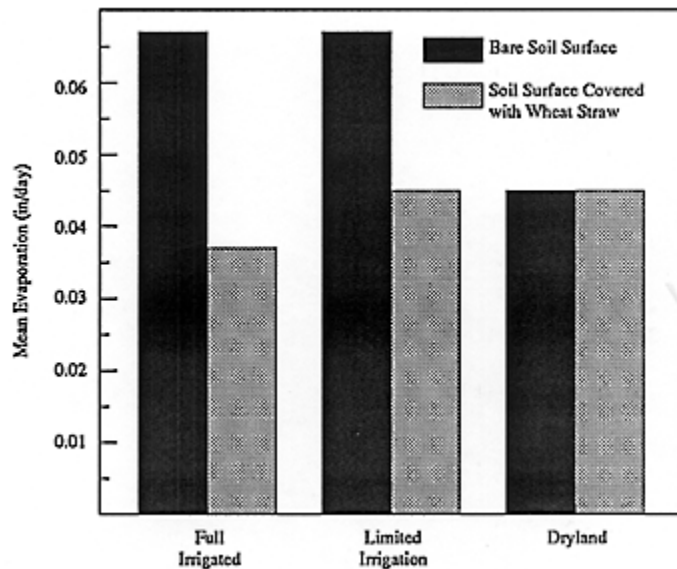


Figure 5. Mean daily evaporation from soil under a corn canopy during the growing season at North Platte, Nebraska (Todd et al., 1991).

Residue also plays a role in soil evaporation with sprinkler irrigation. Residue has the same effect in suppressing evaporation during the non-growing season as in dryland crops. In addition, the soil surface is wet more frequently due to irrigation, which causes more evaporation even with additional shading from denser irrigation canopies.

A field experiment conducted at North Platte, Nebraska, documented the effects of residue on soil evaporation in irrigated corn. The

crop residue was wheat straw (6 tons per acre) lying flat on the surface, which produced complete cover of the ground. Fully irrigated plots were irrigated 9 times during the season and limited irrigation plots were irrigated 3 times. Soil evaporation was reduced 2 to 2.5 inches during the growing season by the wheat residue (see Figure 5). If water were a limiting factor for yield, this savings would represent 20 to 25 bushels of corn per acre. Less evaporation savings would be expected from corn residue since it does not cover the surface completely. However, some savings are possible from partial residue cover, especially when the soil is wet frequently as with sprinkler irrigation.

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