If irrigators can stay up with the water needs of their crop by using only in-season applications of irrigation water, that is the best, most efficient use of irrigation.

However, this is not always the case. In a hot, dry year, crop needs may outpace the ability of the irrigation system to supply water. Reduced well capacity and lower water tables can also make it difficult for irrigators to meet the crop’s needs strictly from in-season irrigation applications.

For these reasons, some irrigators with medium- to fine-textured soils like to make use of their available water supplies during the off-season by making an irrigation application before the crop is planted. This allows them to make sure the soil water profile is in good shape before the growing season begins, in hopes that this will help their irrigation system better keep up with crop demand during the growing season. In this way, “off-season” irrigation applications can be a form of insurance.

Such off-season irrigation applications are almost always less efficient than in-season irrigation applications, but that’s a tradeoff that some irrigators are willing to accept. Water applied during the off-season can be lost due to drainage from the soil profile or through evaporation. This applied water may also become unnecessary if there is an unusually heavy amount of precipitation during the spring that would have filled the profile even without the off-season irrigation.

It’s not possible to completely eliminate any risk of inefficiency from off-season irrigation. The question is, how inefficient is off-season irrigation likely to be under various situations? And how can producers maximize the efficiency of these applications?

There are three main factors that determine the efficiency of off-season irrigation on medium- to fine-textured soils:

* The amount of precipitation that falls between the time of the off-season irrigation application and the time of use by the crop,
* The amount of time between the off-season application and the time of use, and
* The amount of water in the soil profile at the time of the off-season application.

Normally, the amount of precipitation that falls during the off-season before the crop is planted is relatively low in Kansas, in areas where irrigation is most common. So that’s often not a major factor.

Our models show that there is some loss of off-season irrigation efficiency when the application is made during the fall compared to early-spring applications. The difference in efficiency is illustrated in the chart below.

![Graph showing storage efficiency of water from time of irrigation application (fall or early spring) until May 15 at various levels of profile soil water, as percent available water (AW).](image)

The greatest effect on storage efficiency of water applied during the off-season, however, is the amount of available water in the soil at the time of the off-season application. Efficiency begins to drop off dramatically when the percent available water in the soil profile is greater than 60 percent at the time of application. If the soil profile is at 70-80 percent of available soil water, irrigators would want to seriously consider whether an off-season application is wise, especially in the fall. The efficiency of such an application under those conditions is very low.

It should be repeated that in-season irrigation applications are always the more efficient. Off-season irrigation, even at its most efficient, should be considered only if it is likely that in-season irrigation won’t be able to keep up with crop needs.
2. Impacts of no-till on water quality

It is readily accepted that reducing tillage leads to less soil erosion and sediment loss from crop fields. The effects of adopting no-till on the loss of pesticides and nutrients from crop fields are not fully understood and results are mixed. In some cases, research studies find that shifting from a tilled to a no-till cropping system reduces runoff and leaching of pesticides and nutrients. Kansas State University researchers have studied the water quality effects that occur as farmers shift to no-till systems.

**Water runoff amount**

Studies comparing water runoff and tillage in eastern Kansas often find greater water runoff with no-till than conventional tillage in the first runoff event following spring planting. In subsequent runoff events, similar levels of water runoff occur with either tillage system.

The greater water runoff in no-till in the first runoff event may be explained by two different possibilities. The first possibility is that crusting in no-till due to rainfall before planting may cause the higher water runoff. The other possibility is that near the soil surface of no-till fields in eastern Kansas, the fields are often at field capacity for moisture at planting time so greater water may run off in the first storm event.

In contrast, in tilled fields, the tillage before planting may dry the surface soils at planting so there is less runoff in the first storm event following planting. In central and western Kansas, because of less potential for fields being at field capacity for moisture at planting time, one would not expect there to be as much potential for greater water runoff from no-till in the first runoff event compared to tilled soils.

**Suspended solids**

No-till management practices can significantly reduce soil erosion and sediment loss from crop fields. Studies in northeast Kansas on a Grundy silty clay loam soil with continuous corn in a field with 3 percent slope found annual sediment loss of 10.7 tons per acre when using disk tillage compared to annual sediment loss of 0.20 tons per acre with no-till (see Table 1). At Ottawa, in east central Kansas, annual sediment losses with a grain sorghum/soybean rotation in a field with 1 percent slope found annual sediment losses of 0.8 tons per acre with a chisel-disk tillage system and 0.3 tons per acre with a no-till system.

<table>
<thead>
<tr>
<th>Table 1. Effect of Tillage System on Water, Sediment, and Atrazine Runoff in Continuous Corn: Brown County, 3-year average</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tillage system</strong></td>
</tr>
</tbody>
</table>

Full details on this topic can be found in a 2008 paper in the Agronomy Journal (Volume 100, Issue 4, pages 1185-1192). This paper is co-authored by K-State researchers Loyd Stone, Freddie Lamm, Alan Schlegel, and Norman Klocke.

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Nutrients

Phosphorus. Phosphorus can move into surface waters associated either with soil particles during erosion or as soluble phosphorus with runoff water. Greater than 75 percent of the phosphorus in surface water is associated with or bound to soil particles. Much less is soluble phosphorus. The most effective way to reduce phosphorus pollution of surface water is to reduce soil erosion. No-till reduces total phosphorus losses by approximately 40 percent. Total phosphorus consists primarily of insoluble phosphorus attached as soil particles, freestanding inorganic compounds, and soluble phosphorus.

No-till generally has higher losses of soluble phosphorus than do tilled systems. To reduce losses of soluble phosphorus under no-till systems, phosphorus fertilizers should be deep banded or placed near the seed. Using recommended BMPs for phosphorus will minimize phosphorus losses from no-till fields.

<table>
<thead>
<tr>
<th>Tillage system</th>
<th>Total-P</th>
<th>Sediment-P</th>
<th>Soluble-P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chisel-disk, atrazine incorporated</td>
<td>0.92</td>
<td>0.88</td>
<td>0.02</td>
</tr>
<tr>
<td>No-till, atrazine surface-applied and not incorporated</td>
<td>0.69</td>
<td>0.51</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Nitrogen. Nitrogen, in the nitrate form, readily moves with soil water and can move downward as water moves down through the soil profile. More macropores occur in long-term no-till fields than in fields using tillage. Macropores allow greater quantities of water to rapidly infiltrate the soil, causing concerns that the use of no-till may result in greater nitrate leaching to groundwater. However, research in Kansas comparing tillage systems and nitrogen leaching has not found higher nitrate movement with no-till.

Regardless of tillage system, one should always be concerned about nitrate leaching on environmentally sensitive soils, such as sandy soils overlying groundwater supplies and near water sources for human or livestock consumption. Kansas State University recommended BMPs for nitrogen will effectively reduce the potential of nitrate leaching to groundwater.

Pesticides

Some herbicides, such as glyphosate or paraquat, are strongly adsorbed to soil particles, primarily clay and organic matter. Strongly adsorbed herbicides are more likely to leave the field with eroding soil particles and not with the water. Other herbicides, such as atrazine, are weakly adsorbed. Weakly adsorbed herbicides are more likely to leave the field in the water and not with
eroding soil particles. Weakly adsorbed herbicides are also more likely to be leached to groundwater.

No-till will reduce the loss of herbicides that are attached to soil particles by reducing soil erosion, but may have limited value in reducing the loss of weakly adsorbed herbicides from leaving the field. The loss of weakly adsorbed herbicides is generally directly related to water runoff from a field. Generally, the greater the water loss from a field, the greater the herbicide runoff (of weakly adsorbed herbicides).

Regardless of tillage system, it is essential that BMPs be used that will minimize herbicide runoff and leaching. Changing from conventional or reduced tillage to no-till without adopting appropriate herbicide management practices may lead to greater runoff of weakly adsorbed herbicides, such as atrazine. For example, at Powhattan, Kansas, moving from a chisel-disk system that used the atrazine BMP of soil incorporation to a no-till system in which atrazine was applied preemergence increased atrazine runoff by 59 percent over a 3-year period (Table 1). However, changing application timing from preemergence to early preplant (before April 15) reduces potential atrazine runoff by 50 percent.

Further reduction in atrazine runoff can be accomplished by using postemergence applications, which reduces potential atrazine runoff by 67 percent, compared to preemergence applications.

This article is an abbreviated version of the following new K-State publication:
* Impacts of No-Till on Water Quality, MF-2907

For more information on related topics, see the following K-State publications:
* Managing to Minimize Atrazine Runoff, MF-2208
* Best Management Practices for Phosphorus, MF-2321
* Best Management Practices for Nitrogen, MF-2202

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These e-Updates are a regular weekly item from K-State Extension Agronomy and Steve Watson, Agronomy e-Update Editor. All of the Research and Extension faculty in Agronomy will be involved as sources from time to time. If you have any questions or suggestions for topics you'd like to have us address in this weekly update, contact Steve Watson, 785-532-7105 swatson@ksu.edu, or Jim Shroyer, Research and Extension Crop Production Specialist and State Extension Agronomy Leader 785-532-0397 jshroyer@ksu.edu